U.S. ENVIRONMENTAL PROTECTION AGENCY
EPA NEW ENGLAND

RECORD OF DECISION SUMMARY

ELIZABETH MINE

SEPTEMBER 2006

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Record of Decision
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DECLARATION FOR THE RECORD OF DECISION

A. SITE NAME AND LOCATION

Elizabeth Mine Superfund Site
Strafford/Thetford, Orange County, Vermont
VTD988366621
Site ID No: 0102071
EPA Lead

B. STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial action for the Elizabeth Mine Superfund Site in Strafford/Thetford, Vermont (the Site). The remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended (CERCLA), 42 USC § 9601 *et seq.*, and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part 300 *et seq.*, as amended. The Director of the Office of Site Remediation and Restoration (OSRR), United States Environmental Protection Agency New England Region 1 (EPA) has been delegated the authority to approve this Record of Decision (ROD).

This decision is based on the Administrative Record, which has been developed in accordance with Section 113(k) of CERCLA, and which is available for review at the Norwich Public Library, Norwich, Vermont, and at the EPA, OSRR Records Center in Boston, Massachusetts. The Administrative Record Index (Appendix C to the ROD) identifies each of the items comprising the Administrative Record upon which the selection of the remedial action is based.

The State of Vermont concurs with the selected remedy (Appendix C).

C. ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect the public health and welfare or the environment from actual or threatened releases of hazardous substances into the environment.

D. DESCRIPTION OF THE SELECTED REMEDY

This ROD sets forth the first and final selected remedy for the Elizabeth Mine Site. Two additional response actions, a Non-Time-Critical Removal Action (NTCRA) and Time-Critical Removal Action (TCRA), have been selected for the Site earlier by EPA. The remedy selected in this ROD will remediate the five areas of the Site, not addressed by the TCRA or NTCRA, that pose an unacceptable threats to human health and the environment.

The remedy for each of these five areas is summarized below:

Lord Brook Source Area (LBSA), Alternative LBSA 4 – Partial consolidation of surficial mine waste and surface water diversion with discharge of water to tributary of Lord Brook or groundwater. This alternative minimizes the discharge of acid rock drainage (ARD) from the three Lord Brook Source Areas (South Open Cut, South Mine, and TP-4). To accomplish this, exposed waste rock from TP-4 and a portion of the waste rock from the South Mine will be consolidated into the dry portion of the South Open Cut and placed under a cover that will promote surface run-off. The majority of the buried waste rock surrounding the South Open Cut or South Mine will remain in place to minimize disturbance to the forest and the historic features. The amount of material removed from the South Mine area will be determined during design. It is possible that the pit lake within the South Mine may be drained to allow for the removal of waste rock that may be located beneath the pit lake. The South Mine pit lake would be allowed to re-establish itself. The South Open Cut pit lake would also remain and would have an increased water level due to the installation of a dam at the outlet. The design would determine the optimal location for a dam to prevent the uncontrolled release of water from the South Open Cut pit lake. EPA has determined that LSBA 4 is the least damaging practicable alternative to achieve the protection of downstream wetlands and aquatic resources from acid rock drainage. To the extent federally regulated wetlands are identified outside the limits of the waste management area, the altered resources will be restored. The design and construction activities will include measures to minimize the impacts on wetlands through the use of best management practices. EPA has also determined that there will be unavoidable impacts to historic resources. Mitigation measures, if required under applicable historic preservation standards, will be undertaken.

The primary elements of alternative LBSA 4 are:

- Construction of surface water diversions around the South Mine and the South Open Cut/TP-4.

- Excavation of waste ore from the South Mine, with consolidation into the South Open Cut. The amount of material to be re-located will be determined during the design. The objective will be to minimize the extent of disturbance to areas that are not contributing to the acid rock drainage release and to also minimize the impact to historic features. The South Mine pit lake would be allowed to restore itself and serve as a detention basin.

- Excavation of TP-4 waste rock and waste ore with consolidation into the dry portion of the South Open Cut.

- Installation of a dam in the vicinity of the haul road from the South Open Cut to contain the South Open Cut pit lake and allow for a controlled release of water from the pit lake. The dammed pit lake also will inundate additional areas of exposed rock and create conditions that will reduce the production of acid rock drainage.

- Discharge of water from the South Open Cut and South Mine pit lakes via either direct discharge to surface water into the tributary to Lord Brook or infiltration into the ground. Discharge of the water from the South Open Cut to the Underground Workings will also be evaluated. An estimated flow of 2 gallons per minute for the South Open Cut and 5 gallons per minute from the South Mine are estimated as the long-term discharge rates.

- Covering of areas of consolidated mine wastes in the cuts with a vegetative soil cover to act as a contact barrier and to promote vegetative growth and possible addition of lime or other buffering agents.

- Covering areas from which waste rock has been excavated (*e.g.*, TP-4) to promote vegetative growth and possible addition of lime or other buffering agents.

- Performing maintenance and inspections of the covers.

- Performing monitoring of the unnamed tributaries of Lord Brook and Lord Brook to determine if the actions have restored these waters to federal Clean Water Act and Vermont Class B Water Quality Standards at compliance points downgradient from the area. Monitoring of groundwater if discharges are infiltrated into the ground.

- Institutional controls, such as restrictive covenants, to protect the cleanup action from damage and to ensure that buried waste rock is not exposed in the future. Periodic inspections would be performed to ensure compliance with the institutional controls.

- A review of the remedy, at a minimum, every 5 years to determine whether the cleanup action remains protective of human health and the environment.

Upper and Lower Copperas Factories (CF), Alternative CF 4 – In-place capping of lead-containing surficial soil and institutional controls. This alternative involves the placement of a two-foot layer of soil over lead contaminated soil within and surrounding the Upper and Lower Copperas Factories to eliminate the human contact risk. Some consolidation of lead contaminated soil may be necessary. In particular, the design will consider whether the Upper Copperas Factory should be consolidated into the Lower Copperas Factory and if the TP-3 cleanup action would require removal of the Upper Copperas Factory. Both the Upper and Lower Copperas Factories are considered to be within one Area of Contamination and consolidation of material would not trigger federal or state land disposal restrictions or other placement requirements. The design and construction activities will attempt to preserve the exposed foundations of the Copperas Factories as visible features. EPA has determined that CF 4 is the least damaging practicable alternative with respect to the potential unavoidable impacts to federally regulated wetlands. To extent federally regulated wetlands are identified outside the limits of the waste management area, the altered resources will be restored. The design and construction activities will include measures to minimize the impacts on wetlands through the use of best management practices. EPA has also determined that there will be unavoidable impacts to historic resources. Mitigation measures, if required under applicable historic preservation standards, will be undertaken. Long-term groundwater monitoring of the CF covered area, to determine that lead is not leaching into groundwater and exceeding federal and State groundwater standards, will be conducted as part of the Site-wide Groundwater, SW 2 component of the remedy.

The primary elements of alternative CF 4 are:

- Placement of a sufficiently thick soil cover over contaminated soil with a lead concentration equal to or exceeding 400 mg/kg to prevent direct human contact risk.

- Preserve Copperas Factory foundations to the extent possible or documentation of historic resources that must be disturbed.
- Preservation of historic artifacts, to the extent practicable.
- Performing maintenance and inspections of the covers.
- Institutional controls, such as restrictive covenants, to protect the cleanup action from damage. Periodic inspections would be performed to ensure compliance with the institutional controls.
- A review of the remedy, at a minimum, every 5 years to determine whether the cleanup action remains protective of human health and the environment.

Impacted Sediment (SED), Alternative SED 2 – Monitored natural recovery. This alternative relies upon natural processes, such as long-term burial and dispersion to change the distribution of contaminated sediments. The long-term result will be that the sediments are no longer toxic to aquatic organisms and the sediments do not cause the surface water to fail Vermont Class B Water Quality Standards. The NTCRA and LBSA cleanup actions will eliminate the contaminant loading to Copperas Brook, WBOR, and the unnamed tributaries of Lord Brook, also reducing the acidity of the water and the leaching of contaminants into the waters. There would be no construction activities associated with this alternative. EPA would perform an initial baseline surface water, sediment, and biological monitoring program. Long-term monitoring of surface water, sediment, and the biological community would be performed. It is possible that some minor impacts to wetland areas could occur in order to perform the monitoring program. These impacts would be minimized by best management practices and impacted areas would be restored. EPA has determined that SED 2 is the least damaging practicable alternative with respect to the potential unavoidable impacts to federally regulated wetlands, since a sediment removal alternative would disturb wetland and aquatic resources along the waterways. There will be a review of the remedy, at a minimum, every 5 years until sediment and water quality standards are achieved to determine whether the cleanup action remains protective of human health and the environment.

World War II-Era Infrastructure Area (IA), Alternative IA 4 – Limited action (institutional controls and monitoring). This alternative relies upon the successful implementation of the NTCRA to achieve Vermont Water Quality Standards at the point of compliance in Copperas Brook, downstream of TP-1. As a result, the only necessary activities to prevent an increase in acid rock drainage will be monitoring of the water quality at the compliance point, along with implementation and monitoring of a land use restriction that restricts any alteration of the WWII-Era Mine Infrastructure Area in a manner that would expose waste rock and create additional acid rock drainage. The only costs associated with this alternative would be the actions to implement the land use restrictions, monitoring, and to review this remedy, at a minimum, every five years. Periodic inspections would be performed to ensure compliance with the institutional controls.

Site-wide Groundwater (SW), Alternative SW 2 - Monitoring and institutional controls. This alternative includes land use restrictions to prevent future consumption of contaminated groundwater in limited areas of the Site. The contaminated groundwater is found within the Underground Workings of the Elizabeth Mine and within and adjacent to TP-1, TP-2, and TP-3. The TP-1 groundwater restriction may also extend into some of the WWII Infrastructure Area, depending on the extent of the final cover for TP-1. Some combination of local ordinances, deed notices, and/or restrictive covenants, coupled with periodic monitoring of compliance of the restrictions, would be used to provide awareness that the Underground Workings contain water that is unsuitable for ingestion and to prevent installation of a water supply well into the Underground Workings. No residential wells are currently installed in the Underground Workings. EPA is invoking a statutory Technical Impracticability Waiver, as permitted by CERCLA, for the groundwater within the Underground Workings. EPA has determined that it is technically impracticable, from an engineering perspective, to achieve Federal Safe Drinking Water Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) 40 C.F.R. Parts 141.11-.16 and 141.50-.53, and the State of Vermont Primary Groundwater Quality Standards, VT Env. Prot. R. Ch. 12-702 and 703 for the water within the Underground Workings (mine pool). Therefore, EPA is waiving these standards as applicable or relevant and appropriate requirements for the groundwater within the Underground Workings. This waiver applies to all of the inorganic constituents that are present in the naturally occurring material at the Site and specifically to cadmium, copper, manganese, mercury, and nickel which have been detected in the groundwater of the Underground Workings at concentrations above either MCLs, MCLGs, or the Vermont Primary Groundwater Quality Standards.

In addition, institutional controls, in the form of land use restrictions would also be used to prevent future use of the groundwater beneath and adjacent to TP-1, TP-2, and TP-3. One residential well is located within the Waste Management Area for TP-1, TP-2, and TP-3, however, the property is no longer occupied and the well is not currently in use. The groundwater contamination associated with TP-1, TP-2, and TP-3 is restricted to the area under the Waste Management Area. The institutional controls, in the form of land use restrictions, will protect the integrity and long-term effectiveness of the response actions implemented as part of the TCRA and NTCRA. Periodic inspections would be performed to ensure compliance with the institutional controls. The long-term monitoring and maintenance activities for the TCRA and NTCRA will be implemented by the State of Vermont as part of this alternative. This alternative includes the installation of additional monitoring wells to provide long-term compliance points. The number and location of the wells will be determined during the design. Long-term monitoring of the groundwater and discharge of the Underground Workings at the Artesian Vent, adjacent to the West Branch of the Ompompanoosuc River, would also be included in this alternative. In addition, groundwater around the lead contaminated soil cover in the Upper and Lower Copperas Factories area, adjacent to TP-3, will be monitored to determine that the covered contaminants are not causing exceedances of federal or State groundwater standards. It is possible that some impacts to wetlands and floodplain areas could occur to allow for the installation of the monitoring wells. These impacts would be minimized by best management practices and impacted areas would be restored. There will be a review of the remedy, at a minimum, every 5 years to determine whether the cleanup action remains protective of human health and the environment.

E. STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with federal and State requirements that are applicable or relevant and appropriate to the remedial action (unless justified by a waiver), is cost-effective, and utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable.

The remedy is not able to achieve the statutory preference for treatment as a principal element of the remedy (i.e., reduce the toxicity, mobility, or volume of materials comprising principal threats through treatment) due to site conditions and the balancing all of the CERCLA criteria for selecting remedial alternatives.

Because this remedy will result in hazardous substances remaining on-site above levels that allow for unlimited use and unrestricted exposure (including groundwater use restrictions and measures to protect covers over contaminants left on site) a review will be conducted within five years after initiation of remedial action and, at a minimum, every five years after that date, to ensure that the remedy continues to provide adequate protection of human health and the environment.

F. SPECIAL FINDINGS

EPA is invoking a statutory Technical Impracticability Waiver, as permitted by Section 121(d)(4)(C) of CERCLA, 42 U.S.C. § 9621(d)(4)(C), for the groundwater within the Underground Workings. EPA has determined that it is technically impracticable, from an engineering perspective, to achieve federal Safe Drinking Water MCLs and MCLGs and Vermont Primary Groundwater Quality Standards for the water within the Underground Workings (mine pool). Therefore, EPA is waiving these standards as applicable or relevant and appropriate requirements for the groundwater within the Underground Workings. This waiver applies to all of the inorganic constituents that are present in the naturally occurring material at the Site and specifically to cadmium, copper, manganese, mercury, and nickel which have been detected in the groundwater of the Underground Workings at concentrations above either MCLs, MCLGs, or the Vermont Primary Groundwater Quality Standards. The primary basis for this finding is that the source of the contamination, the wall rock and waste rock within the Underground Workings, will generate the condition that causes the water to exceed the standards for hundreds, if not thousands of years. While it would be practicable to collect and treat the discharge from the Underground Workings or to prevent the spread of the contamination from the Underground Workings into the adjacent aquifer, EPA has determined that there are no practicable actions that would result in the water within the Underground Workings consistently achieving groundwater standards. EPA retains the federal MCLs, MCLGs, and Vermont Primary Groundwater Quality Standards as compliance criteria for the groundwater at the edge of the Technical Impracticability Zone, which is the aquifer surrounding the Underground Workings. EPA has determined that contaminated water within the Underground Workings is not causing the adjacent bedrock aquifer to exceed federal or State drinking water or groundwater standards. Therefore, the proposed remedy incorporating this waiver is protective of human health and the environment as long as land use restrictions are implemented to prevent drinking water wells from being installed that would draw water from the Underground Workings. A more detailed discussion of the Technical Impracticability waiver can be found in Appendix D of the Feasibility Study (FS).

EPA has determined that unavoidable adverse impacts will occur to historic resources at the Site. Direct impacts to the South Open Cut, South Mine, TP-4, and Copperas Factories are necessary to implement the cleanup action. The impacts are in addition to the unavoidable impacts to TP-1, TP-2, and TP-3 that were identified in the Action Memorandum for the NTCRA. The remedy for the Mine Infrastructure Area (World War II era buildings), IA 4, was selected, in part, because it will avoid significant alteration of historic resources in the IA area. The cleanup alternatives all consider ways to avoid or minimize the adverse impacts to the extent practicable. However, since the historic resources are the source of contamination, some impact is necessary to protect human health and the environment.

EPA has determined that there may be unavoidable adverse impacts to wetlands and aquatic resources. To the extent federally regulated wetlands and aquatic resources are located within and adjacent to the South Mine, South Open Cut, TP-4, and Copperas Factories they may be removed and/or altered as part of the cleanup actions. Wherever possible, wetland areas will be re-created. The pit lakes of the South Mine and South Open Cut will be not be eliminated as part of the cleanup action, but some portion of these features may be altered as necessary to implement the cleanup action. The pit lake for the South Open Cut will be used as a detention basin to stabilize flow. The pit lake level will be increased by the installation of a dam to inundate more of the acid generating material on the bedrock walls, which will reduce the toxicity and mobility of the inorganic contamination. The South Mine pit lake will be re-established after the source removal activities. This pit lake will also serve as a component of the cleanup action by acting as a detention basin. Use of the pit lakes as part of the treatment system is justified because the aquatic resource is located within a naturally occurring acid generating material and cannot be restored to meet water quality standards. EPA has evaluated the requirements of the applicable federal Clean Water Act regulations 40 C.F.R 230, and identified the proposed actions as the least damaging practicable alternatives to protect downstream federally regulated wetland and aquatic resources from acid rock drainage.

G. ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this Record of Decision. Additional information can be found in the Administrative Record file for this Site.

1. Chemicals of concern (COCs) and their respective concentrations.

2. Baseline risk represented by the COCs.

3. Cleanup levels established for COCs and the basis for the levels.

4. How source materials constituting principal threats are addressed.

5. Current and reasonably anticipated future land assumptions and current and potential future beneficial uses of groundwater used in the baseline risk assessment and ROD.

6. Potential land and groundwater use that will be available at the Site as a result of the selected remedy.

7. Estimated capital, operation and maintenance (O&M), and total present worth costs; discount rate; and the number of years over which the remedy cost estimates are projected.

8. Key factor(s) that led to selecting the remedy (i.e. describe how the Selected Remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria; highlighting criteria key to the decision).

H. AUTHORIZING SIGNATURES

This ROD documents the selected remedy for the groundwater at the Elizabeth Mine Superfund Site. The State of Vermont Department of Environmental Conservation (the Vermont DEC) concurs with the remedy.

Concur and recommended for immediate implementation:

U.S. Environmental Protection Agency

By: Susan Studlien   Date: 09/28/06

Susan Studlien, Director
Office of Site Remediation and Restoration
EPA New England

RECORD OF DECISION SUMMARY

A. SITE NAME, LOCATION AND BRIEF DESCRIPTION

Elizabeth Mine Superfund Site
Strafford/Thetford, Orange County, Vermont
VTD988366621
Site ID No: 0102071
EPA Lead

The Elizabeth Mine Superfund Site is located in the Towns of Strafford and Thetford, Orange County, Vermont in east-central Vermont, approximately two miles southeast of the village of South Strafford, on the eastern flank of Copperas Hill. It is approximately 15 miles northwest of White River Junction, VT, and 9 miles west of the Connecticut River. Approximately 272 persons live within one mile of the Site and 2,500 within four miles. The location of the Elizabeth Mine and the study area subject to investigation as part of the Remedial Investigation is shown on Figure 1.

The Site includes three small watersheds containing Copperas Brook, Lord Brook, and Sargent Brook, which all discharge to the Ompompanoosuc River. All of the surface water is State-designated as a Class B water. The Ompompanoosuc River flows into the Connecticut River about ten miles downstream of the Site. The topography of the area is steep mountainous terrain with elevations ranging from 940 feet above mean sea level (msl) at the West Branch of the Ompompanoosuc River (WBOR) to 1600 above msl at the top of Copperas Hill.

A more complete description of the Site can be found in Section 1 of the Remedial Investigation Report prepared by URS Corp for EPA New England and released in July 2006 (RI).

B. SITE HISTORY AND ENFORCEMENT ACTIVITIES

1. History of Site Activities

The industrial history of the Elizabeth Mine began with the discovery of a massive sulfide ore body along a ridge located southeast of South Strafford village in 1793. The mine was initially worked for the sulfide mineral pyrrhotite to manufacture copperas. Copperas is a crystalline green hydrous iron sulfate that has been used for a variety of purposes including: production of sulfuric acid; a disinfectant and sheep dip; astringent medicine; to blacken and color leather; and as a drier in ground pigment manufacturing. Major production of copperas began about 1809 and ended in the 1880's. The source material for the copperas production was surface-exposed ore located in the area of the North Open Cut. Some time around 1829 development of the Underground Workings was initiated to more efficiently access the ore body. The copperas production area includes 12 acres at the top of the Copperas Brook watershed adjacent to the North Open Cut. This area contains colorful piles of variably pyrolyzed sulfide ore that are part of the "heap leach" piles from the copperas production. Some of the heap leach piles are overlaid by waste rock from some of the earliest copper mining at the Site. This area is known as tailing pile 3 (TP-3).

Also during the 1800s the mine began to produce copper, with onsite refining (i.e., smelting) processes occurring as early as 1821 in the Furnace Flats area. The mine transitioned entirely to copper extraction and processing during the 1880s. While little historical information exists, it is likely that the South Mine was also developed as a source of ore during the middle 1800s.

The flotation process was reportedly first implemented onsite to produce copper in 1916, however the mine only operated intermittently through the 1920s and 1930s until it was reopened in 1942. As part of the World War II-era operations, a complex of mine buildings was built including a crushing plant and a modernized flotation mill. Tailing from the WWII-era mining and milling process was deposited within the Copperas Brook valley, resulting in the generation of tailing pile 1 (TP-1) and tailing pile 2 (TP-2). Site operations continued throughout the 1940s and by April 1950 surface and near-surface ore mining was taking place in the neighboring Lord Brook watershed located south of the North Open Cut. Ore extracted from the South Open Cut was added to the ore originating from the Underground Workings to provide raw ore for the mill. Additionally, ore from the nearby Ely Mine was also being trucked to the Site in order to provide additional ore for processing by the flotation mill. Mining operations ceased in 1958. The properties comprising the Site were subsequently sold and have not been further developed.

A more detailed description of the Site history can be found in Section 1 of the RI Report.

2. History of Federal and State Investigations and Removal and Remedial Actions

The Site was proposed for inclusion on the National Priorities List (NPL) in December 2000. The Site was finalized on the NPL on June 14, 2001 (F.R. Vol. 66, No. 116, pages 32235-32242).

In addition to the ongoing RI/FS and upcoming remedial action being undertaken in accordance with Section 104 of CERCLA, EPA had previously implemented both a time-critical removal action (TCRA) and a non-time-critical removal action (NTCRA) consistent with Section 300.415 of the NCP. The removal actions, as described below, were necessary because EPA made determinations that conditions at the Site represented an imminent or substantial threat to public health or welfare of the United States or to the environment.

Time Critical Removal Action

Geotechnical investigations and evaluations performed during 2002 identified significant stability concerns associated with the TP-1 tailing dam. The consequence of a failure of TP-1 would be the release of large quantities of tailing that could threaten up to 11 downstream structures and impact up to 20 miles of river with anoxic tailing. Three mechanisms for the failure or collapse of the TP-1 tailing dam were identified:

- internal dam erosion (or piping);
- failure of the decant system resulting in overtopping or elevated levels of tailing saturation within the tailing dam; and,
- slope failure due to surface erosion or due to an increase in the water table within TP-1 resulting from other factors (i.e., not decant system related).

Frequent site inspections of TP-1 were initiated in February 2003. Internal dam erosion was identified to be accelerating during these inspections. As a result of these identified conditions and following meetings with local officials and the public, a TCRA was implemented at TP-1 by EPA during three separate construction phases. The TCRA actions were implemented to increase the stability of TP-1 and reduce the potential for a dam failure, which posed a public health threat to inhabitants of downstream areas. The phased-implementation of the TCRA was to accommodate work sequencing and seasonal limitations. Phase 1 included readily implementable critical elements, Phase 2 included activities implementable during the initial construction season, and Phase 3 included elements that could be implementated during subsequent construction seasons. As an interim measure prior to Phase 1, EPA mobilized high capacity pumps to the Site to provide stand-by, by-pass capacity in the event that the decant system became blocked or otherwise failed. In conjunction with the TCRA, EPA developed an Emergency Response Plan in coordination with local response officials.

The phases of the TCRA, as well as the inferred effects on Site conditions, are described in the following subsections. The components of the completed TCRA are depicted on Figure 2.

Phase 1 – Spring 2003

Phase 1 of the TCRA was performed in the spring of 2003 and included installing an access road along the western edge and northwestern corner of TP-1 and placement of temporary graded filters to mitigate piping at the toe of TP-1. Sand and stone filter blankets were constructed in areas of seepage where piping of tailing materials was occurring, including the area at the base of the starter dam. The access road, which included temporary culverts to channelize surface water flow, had a localized effect on surface water flow patterns at the base of TP-1.

Phase 2 – Fall 2003

Phase 2 of the TCRA was performed during the fall of 2003 and included installing a 36-inch diversion pipe and spillway to replace the existing decant drainage system that formerly transmitted Copperas Brook through the lower portion of TP-1. The diversion construction included installing a groundwater interception pipe to intercept shallow groundwater entering TP-1 from the east. The inlet/outlet structures and the diversion pipe increased flow capacity for Copperas Brook to pass through TP-1. As a result, the decant pond on the surface of TP-1 was reduced in size and the residence time of Copperas Brook on the tailing surface of TP-1 was reduced.

Phase 3 – 2004 - 2005

Phase 3 of the TCRA was performed during the 2004/2005 construction seasons and included construction of a soil buttress to stabilize the north face of TP-1. The buttress construction involved the placement of approximately 67,000 cubic yards of soil obtained from both onsite and offsite sources. Additional and associated elements of the TCRA Phase 3 buttress construction included:

- Clearing of approximately 15 acres north and east of the crest of TP-1 (including borrow area development);
- Removal of approximately 30,000 cubic yards of surficial tailing materials from the toe of TP-1 with this material being relocated to the surface of TP-1;
- Installation of a seepage collection system within the buttress and installation of sedimentation basins located between the buttress and Copperas Brook;
- Grading the upper face of TP-1 above the buttress to flatten the slope and provide for controlled drainage;
- Grading of the surface of TP-1 to accommodate drainage control to the decant outlet (this included removal of a portion of the volunteer vegetation on TP-1); and,
- Establishment of vegetation on critical surfaces, including the buttress face and the upper graded slope to provide stabilization and to limit erosion.

During construction, multiple former wooden decant structures were identified at the toe of TP-1. Where encountered, these features were retrofitted with discharge pipes to transmit groundwater from the decant structures through the buttress and into the constructed surface water collection features. The TCRA was completed in fall 2005. The State of Vermont has taken over responsibility for the post removal site control for the TCRA. Long-term operation and maintenance of the TCRA structures has been incorporated into this remedy.

Non-Time Critical Removal Action

In March 2002, EPA presented a proposed plan for a NTCRA as an early cleanup action to control the primary sources of ARD at the Elizabeth Mine. The NTCRA resulted from a determination by EPA that Copperas Brook and the WBOR were a threat to public health or welfare of the United States or to the environment. This determination was based upon information gathered during preliminary assessments of Copperas Brook and the WBOR during 2000 and 2001. Based on the implementation schedule of the NTCRA (providing for a 6-month planning period), in 2002 an Engineering Evaluation and Cost Analysis (EE/CA) was prepared, as required by NCP Section 300.415(b)4(i). A fact sheet presenting details of the proposed early cleanup response was released for public comment in March 2002.

The cleanup objectives developed by EPA for the NTCRA were as follows:

- Achieve Vermont Water Quality Standards (VWQS)(chemical and biological), VT Nat. Res. Brd., Water Res. P. 12-004-052, as well as other applicable standards in the WBOR by preventing or minimizing discharge of water with mine-related metals contamination to Copperas Brook and to the WBOR;

- Minimize the erosion and transport of tailing or contaminated soil into the surface waters of Copperas Brook and the WBOR;
- Evaluate the stability of waste piles (i.e., tailing, waste rock, and leach piles) and modify slope configurations (regrading, covering, or buttressing) as necessary to provide for an acceptable level of long-term stability;
- Consider measures to minimize and avoid any adverse effect on historic resources at the Site, as required by the National Historic Preservation Act (NHPA), 16 USC §470 *et seq.*; and
- Comply with all applicable federal and state regulations.

EPA's stated goal for the NTCRA was protection of human health and the reduction of ecological risks to levels that would result in the recovery and maintenance of healthy local populations and communities of biota.

EPA evaluated a range of technologies for controlling and/or treating ARD in an Alternatives Analysis Report, and concluded that source control was the preferred approach by the regulatory agencies and mining experts. Source control options evaluated included submergence (under water) and cover techniques. EPA noted that collection and treatment of ARD would be needed to address residual drainage after source control and for areas where source control was not practical. Three natural system approaches for treatment of ARD were evaluated (i.e., passive pH adjustments, anaerobic wetlands, and aerobic wetlands) and different combinations of source control and treatment technologies were assembled.

The EPA created five cleanup alternatives for evaluation in the EE/CA. All five alternatives were evaluated for effectiveness, implementability, and cost. Key regulatory requirements included in the evaluation were the NHPA; the Clean Water Act (CWA), 33 USC §1251 *et seq.*; the VWQS; and the Vermont Solid Waste Management Rules (VTSWMR), VT Env. Prot. R. Ch. 6.

After completing the EE/CA for the five retained alternatives, EPA selected Alternative 2C as the preferred cleanup action to achieve initial site objectives. The EE/CA and the fact sheet summarizing the proposed response action were made available for comments during a 30-day comment period held from March 15 to April 15, 2002. After consideration of comments received, EPA signed an Action Memorandum on September 3, 2002 to document the activities to be performed as part of the NTCRA. The selected and agreed upon remedy requires the following actions:

- Surface water and groundwater diversion ditches – The installation of diversion ditches around the perimeter of TP-1, TP-2, and TP-3 to intercept and divert clean water around the tailing piles and waste rock/heap leach piles, to prevent clean water from coming into contact with the sulfide-bearing materials, and to intercept shallow groundwater that may be flowing into the tailing piles.
- Slope stabilization – Performance of design studies to determine stabilization requirements for the steep slopes of TP-1 and TP-2.
- Infiltration barrier cover system – The installation of an infiltration barrier cover over TP-

1 and TP-2, likely consisting of a soil/vegetation layer, a drainage layer, a primary barrier, and possibly a secondary barrier to prevent water and oxygen from contacting the tailing, thus minimizing the ARD generation as seepage at the toe of TP-1.

- Collection and treatment of the seeps along the toe of TP-1 – The installation of a collection system to capture the seeps that discharge ARD along the toe of TP-1, and a combination of aerobic and anaerobic biological treatment systems to treat the water.
- Preservation of a portion of TP-3 – Intact preservation of a portion of TP-3, with no cover or substantial regrading within the preserved area. Some limited work will likely be needed to minimize the erosion in the preservation area. Since the maintenance costs associated with the preservation of TP-3 will be paid for by the State of Vermont, EPA deferred to the State for a determination regarding the extent of TP-3 to be preserved.
- Collection and treatment of run-off from TP-3: Collection of surface water run-off from the preserved portion of TP-3 in an interceptor trench installed along the downgradient edge of the waste rock and heap leach piles and treatment of the run-off using a combination of aerobic and anaerobic biological systems.

Greater details regarding the water treatment and infiltration barrier cover systems are provided in the Action Memorandum for the Elizabeth Mine Site. The preservation of a portion or all of TP-3 as an option was further considered during 2003. In 2003, the Commissioner of the Vermont DEC and the State Historic Preservation Officer (SHPO) announced that the State of Vermont could not financially support a cleanup approach that relied upon collection and treatment of surface water run-off, if such collection and treatment measures resulted in a substantial increase in the financial burden to the State of Vermont. As a result, the NTCRA design will focus on minimizing any costs associated with the treatment of water discharging from TP-3.

The extent of the area that will be subject to the NTCRA is depicted on Figure 2. In the summer of 2005, EPA allocated funds to initiate the design of the NTCRA. EPA also identified a subset of NTCRA activities that may be implemented during the design of the major components of the NTCRA. These initial NTCRA activities will include those components of the NTCRA that are considered ready for implementation and only require minimal design and planning efforts. The remaining NTCRA activities will include those components that require more substantial design efforts to determine the most cost-effective way to implement these measures. The effect of the NTCRA on conditions in the Site will be to eliminate the significant sources of ARD impacts and sediment transport of ARD-generating source materials to Copperas Brook and to downgradient reaches of the WBOR and the Ompompanoosuc River.

Remedial Investigation and Feasibility Study

EPA began a remedial investigation and feasibility study (RI/FS) at the Site in 1999. The RI/FS is described in the RI Report and the key findings are presented in Section E of this ROD. The RI/FS was completed with the issuance of the Proposed Plan for this ROD in July 2006.

3. History of CERCLA Enforcement Activities

Enforcement activities have been limited, to date. Determining liability for the Site is complicated by the nearly 50 years that have passed since the closure of the Elizabeth Mine in 1958. EPA continues to investigate whether potentially liable and viable successors to the now defunct former operators may exist. There are 7 separately owned properties that include some portion of the waste areas (TP-1, TP-2, TP-3, TP-4, South Mine, South Open Cut, and North Open Cut) at the Site. EPA has entered into a settlement with one of the current landowners and is currently negotiating with other landowners.

C. COMMUNITY PARTICIPATION

Throughout the EPA cleanup of the Site, community concern and involvement have been high. To address community concerns and to serve as a focal point for discussion with EPA, the Elizabeth Mine Community Advisory Group (EMCAG) was formed in April 2000. It consists of ten member organizations representing a cross section of the community.

The EMCAG member organizations are:

- Town Strafford Selectboard
- Town of Thetford Selectboard
- Elizabeth Mine Study Group (EMSG)
- Citizens for a Sensible Solution (CASS)
- Elizabeth Mine Survivors
- Adjacent Landowners and Residents
- Non-residential Landowners
- Thetford Conservation Commission
- Strafford Planning Commission
- Strafford Historical Society

The EMCAG has been actively engaged in a dialogue with EPA and Vermont DEC for over six years. The EMCAG provided input to shape the NTCRA, TCRA, and the RI/FS. The commitment and perseverance of the EMCAG members is a testament to the community's desire to be integral part of the cleanup action at the Site. Working with the EMCAG, EPA developed a process for extensive community involvement in shaping the cleanup at the Site. EPA provides the EMCAG with technical briefings presenting design plans, descriptions of investigation programs, and results of studies and investigations in advance of the formal reports. The alternatives under consideration in the RI/FS were presented to the EMCAG six months prior to the public comment period. EPA took the input from the community into consideration in the development and evaluation of the cleanup options. EPA continues to meet regularly with the EMCAG. In developing this ROD, specific public involvement activities have included:

- EPA met with the EMCAG on a nearly monthly basis during 2000, in May, June, August, September, October, and December of 2001, and January and March of 2002 as part of the discussion of the initial RI/FS activities and the development of the

NTCRA.

- After the NTCRA comment period in March 2002 and the signing of the NTCRA Action Memorandum in September 2002, EPA continued to meet regularly with the EMCAG
- Meetings between EPA and the EMCAG to discuss the implementation of the NTCRA and the RI/FS were held in: October 2002; April, May, June, August, and September of 2003; January, May, and November of 2004; January, June, and November of 2005; and January, May, and June of 2006.
- The EMCAG also met with the State of Vermont DEC on March 30, 2006 to discuss the RI/FS.
- EPA held a public information meeting to present the RI/FS and Proposed Plan on July 11, 2006
- EPA held a public comment period from July 11, 2006 to August 11, 2006 to accept public comment regarding the Proposed Plan.
- As part of the public comment period, EPA held a public hearing on August 1, 2006 to accept public comment regarding the Proposed Plan

To further support community involvement, EPA has provided the community with technical resources through the Technical Assistance Grant (TAG) and the Technical Outreach Services to Communities (TOSC) programs. These programs provided the community with independent university and private professional experts to evaluate the EPA Reports. EPA also provided the Towns of Strafford and Thetford with a Redevelopment Initiative Grant which was used to hire experts to assist in evaluating future use options for the Site once the cleanup is complete. EPA will continue its dialogue with the public, EMCAG, and local authorities during the implementation of the cleanup actions called for in this ROD.

The comments received as part of the public comment period were generally supportive of the proposed cleanup action (See Appendix C). Several comments were received relating to the ongoing NTCRA activities rather than the Proposed Plan.

D. SCOPE AND ROLE OF OPERABLE UNIT OR RESPONSE ACTION

The remedy described in this ROD will be the third response action as well as the first and final remedial action for the Site (the ongoing NTCRA and the completed TCRA are the other two response actions). The selected remedy was developed by evaluating a range of alternatives for five areas of the Site to obtain a comprehensive approach to addressing all remaining CERCLA human health and environmental risks at the Site. The response actions at the Site fall into three categories: completed response actions; ongoing response actions; and the remedial action described in this ROD.

Completed Response Actions – TCRA

- Installation of diversion pipe to carry Copperas Brook around TP-1
- Installation of buttress to stabilize the north face of the Tailing Dam at TP-1
- Grading of Tailing Dam above buttress to stabilize the slope on TP-1

Ongoing Response Actions – NTCRA

- Grading and stabilization of the west side of the Tailing Dam at TP-1
- Diversion of surface water and groundwater around TP-1, TP-2, and TP-3
- Installation of a cover system for TP-1 and TP-2
- Waste re-location, grading, and cover placement at TP-3
- Collection and treatment of seeps at TP-1
- Collection and treatment of residual run-off from TP-3 (as necessary)

The NTCRA, TCRA, and Remedial Action all overlap within the Site area that includes TP-1, TP-2, and TP-3. TP-1 was the focus of the TCRA. The containment of the waste materials comprising TP-1, TP-2, and TP-3 and the treatment of the associated surface water discharge/seeps from these areas are the focus of the NTCRA. The Remedial Action described in this ROD targets five areas of the Site. The designation for each Site area and a brief description is presented below:

- Site Wide Groundwater (SW): This area includes groundwater contamination associated with TP-1, TP-2, and TP-3 and the contaminated groundwater within the Underground Workings;
- Upper and Lower Copperas Factories (CF): The soil contamination located at the Upper and Lower Copperas Factories that are adjacent to TP-3;
- Sediments (SED): The contaminated sediments of Copperas Brook, the WBOR, unnamed tributaries to Lord Brook; and Lord Brook;
- World War II- Era Infrastructure Area (IA): An area with the remnants of the 1942-1958 ore processing facilities that is located on a plateau of waste rock; and
- Lord Brook Source Areas (LBSA): Three areas, South Open Cut, South Mine, tailing pile 4 (TP-4)) that are the primary source of acid rock drainage to Lord Brook.

The Remedial Action also includes the long-term monitoring, operation, and maintenance of the NTCRA and TCRA as wells as the institutional controls required to protect the NTCRA and TCRA. These response areas of the Site are shown in Figure 3.

With respect to the principal threats at the Site, the Site is a mining Site with large areas of acid generating, metal rich, waste rock and tailing. The only principle threat waste is lead remaining in the soil surrounding the Copperas Factories. The remaining waste is considered low level threat waste that will be addressed through a combination of engineering controls and administrative controls, including containment, land-use restrictions, and natural processes, along with some limited treatment in some areas.

The remedy for the Site provides for the restoration of the impacted aquatic ecosystems and containment of the wide spread, low-level threat waste. The remedy includes a technical impracticability waiver for the groundwater within the Underground Workings of the mine. Institutional controls will be implemented and regularly monitored to control site use, particularly groundwater ingestion and disturbance of the containment systems. Environmental monitoring will be implemented to evaluate the success of the cleanup and provide information for the statutorily required five-year reviews.

E. SITE CHARACTERISTICS

The existing and former mine features result from the mining and mineral processing of the besschi-type massive sulfide ore body which is part of the Vermont Copper Belt. The primary physical features associated with the mine include three open rock cuts (the North Open Cut, the South Open Cut, and the South Mine), two pit lakes (located at the South Open Cut and at the South Mine), two tailing dams (designated TP-1 and TP-2), waste ore and waste rock piles (including the waste areas designated TP-3 and TP-4), a series of World War II (WWII)-era mine support buildings, and approximately 8,000 linear feet of underground mine workings. The area subject to the RI also includes areas of historic ore benification processes (including smelter sites and roast beds) and areas of graded mining wastes used as historic fill. Figure 4 depicts the areas of historical mining activity that were investigated as potential source areas.

Chapter 1 of the FS Report contains an overview of the RI. The significant findings of the RI Report are summarized below.

1. General Characteristics

EPA performed a series of investigations to develop an understanding of the nature and extent of contamination at the Site. A brief summary of the area wide characteristics is presented followed by a more specific discussion of the Site source areas along with the nature and extent of contamination.

Meteorological Conditions

The Site is located in the northeastern climatological region of Vermont. Average temperatures vary locally due to elevation, topography, and urbanization. Based on data collected between 1971 and 2000, average temperatures for the region for January, April, July, and October are 20, 40, 65, and 45 degrees Fahrenheit (°F), respectively. During over two years of meteorological monitoring at the Site (*i.e.*, 2002 through 2004), a maximum temperature of 95 °F and a minimum temperature of -26 °F were recorded.

Area winds primarily consist of the prevailing westerlies (i.e., a northwesterly flow in the winter and a southwesterly flow in the summer). The local wind conditions are influenced by the topography and as such the prevailing winds at the Site blow parallel to the valley (*i.e.*, south). The contrasting air brought into the region by the westerlies interacts to produce localized low-pressure storm systems that cause wide variations in precipitation from one part of the region to another. For this reason, the rainfall at the Site may be significantly different from that measured at the Union Village Dam weather station, as can be observed in the existing data records.

Precipitation is received in fairly uniform amounts throughout the year. Most of the precipitation is generated by frontal systems. During the summer, thunderstorms are responsible for the heaviest local rainfall intensities. During the years of meteorological monitoring at the

Site, rainfall events of up to four inches within 24 hours and several significant snowfall events (*i.e.*, greater than 12 inches within 24 hours) have been documented. Average annual precipitation for the region ranges from 36 to 40 inches per year, including an average of 23 inches of snowfall occurring between November and April. Site monitoring has recorded an average annual precipitation of approximately 33 inches per year.

Regional Soil Conditions

The most significant natural event affecting the overburden geology of the Site was the glaciation that covered most of New England within the last 10,000 to 15,000 years. In particular, Orange County was covered by a glacier during the Wisconsinan Glaciation approximately 13,000 years ago. Glacial erosion on ridges where competent bedrock was exposed or covered only by a thin veneer of overburden was minimal. However, the scouring action of glacial ice deepened and widened river valleys during periods of glacial advancement. These same river valleys served as a repository for outwash, glaciofluvial, and glaciolacustrine deposits during times of melting and glacial retreat.

Loose rock and soil scoured from the land during the period of glacial advance were incorporated into the advancing ice mass and then redeposited as glacial till of varying thickness over the bedrock during both the advancing and retreating stages of glaciation. Glacial till encountered at the Site and in the Site area is comprised of a poorly sorted to unsorted, non-stratified mixture of sand, silt, clay, angular gravel, and rock fragments. As the glaciers melted and receded, meltwater reworked and transported some of the sediments that had been incorporated into the ice mass during the advancement of the glacier. These sediments were subsequently redeposited by the meltwater along the valleys widened by the glacier. The Ompompanoosuc River Valley includes glaciofluvial features formed by the melting glaciers (*i.e.*, kames and kame terraces) and glaciolacustrine littoral and lake-bottom deposits. More recently, streams within the drainage basin of the WBOR (including Sargent Brook, Lord Brook, and Copperas Brook) have reworked, transported, and deposited alluvium, consisting predominantly of sand and gravel, along their banks.

Regional Bedrock Geology

The Elizabeth Mine is the southernmost mine in the 20-mile-long, Orange County, Vermont, copper belt that includes the Ely Mine in Vershire and the Pike Hill Mines in Corinth. The metallic sulfide mineral deposits of the copper belt are located in the Paleozoic stratigraphic units of the Connecticut Valley Trough that stretches from western Massachusetts to the Gaspe Peninsula of the Province of Quebec, Canada. The bedrock underlying Orange County consists of Silurian and early Devonian metasedimentary rocks with interspersed metavolcanic rocks and igneous intrusives. These rocks were subjected to at least three stages of intense folding and metamorphism during the early Devonian Acadian orogeny. Rock units typically dip steeply to the east and become progressively younger from west to east. Bedrock at the Site (and the host rock of the ore body) is mapped as the Gile Mountain Formation which consists largely of metamorphosed pelitic schist, greywacke (seafloor sediments), and amphibolite Bedrock to the north and west of the Site consists primarily of the calcareous Waits River Formation, which contains metamorphosed calcareous pelite, pelite, quartzose limestone, dolostone, and limestone.

The Vermont copper belt ore deposits are examples of Appalachian sulfides. These ore deposits consist of iron sulfide in the form of pyrite or pyrrhotite, commonly mixed with lesser quantities of copper, usually in the form of chalcopyrite, and locally zinc (sphalerite), lead, and trace amounts of other metals, including precious metals. The ore mined at the Elizabeth Mine consisted predominantly of pyrrhotite (iron sulfide) with the copper in chalcopyrite (copper iron sulfide), and traces of zinc and silver. The Appalachian sulfide ore bodies are generally understood to have been deposited on the seafloor as thick sulfide ore beds resulting from hydrothermal vents that precipitated metals. These metals leached from country rocks by hot circulating seawater. The sulfide beds were eventually buried by sediments and incorporated into the stratigraphic package. The sedimentary and volcanic rocks were then included and metamorphically altered in the folded mountain ranges, uplifted, and eroded, subsequently exposing them at ground surface. Geologists consider the Elizabeth Mine and other Orange County copper deposits to be examples of a Besshi-type massive sulfide deposit which occur at rifting (spreading) continental plate margins at oceanic ridge crests or back arc marine basins.

Bedrock topography beneath the Site and RI study area generally slopes north/northeast along the Copperas Brook drainage basin toward the WBOR from an elevation of approximately 1,410 feet MSL (surface exposed bedrock at the south end of the North Open Cut) to an elevation of approximately 860 feet MSL at monitoring well location MW-18C. Based upon core samples obtained from beneath and adjacent to TP-1 and TP-2 and adjacent to the South Open Cut, the host bedrock underlying the Site and RI study area is described as schists containing biotite, graphite, and/or garnet, representative of the Gile Mountain Formation. In general, the bedrock within the Site area exhibits a low degree of fracturing with only slight to moderate weathering. As an exception, rock cores obtained just below the bedrock surface were intensely fractured and exhibited a slight to moderate degree of weathering. Many, but not all of the fractures encountered in bedrock at the above-referenced locations were steeply dipping and water-bearing.

Regional Surface Water Hydrology

Regionally, the Site is located within the 136 square mile drainage basin of the 23-mile-long Ompompanoosuc River system. The river system consists of the East Branch of the Ompompanoosuc River (EBOR) and the WBOR that flow into and form the Ompompanoosuc River. The EBOR originates in the northwest corner of the town of Vershire and flows east and south to the southern edge of the town of Thetford. The Ely Mine Superfund Site discharges to Schoolhouse Brook approximately 1.25 miles north of the Schoolhouse Brook confluence with the EBOR. The EBOR then flows about 9 miles south to its confluence with the WBOR. The headwater tributaries to the WBOR originate from Hawkins Mountain (elevation 2,363 feet MSL) in southwest Vershire and Brocklebank Hill (elevation 2,111 feet MSL) in northeast Tunbridge, Vermont. The tributaries meet in the town of Strafford, approximately 5.8 miles northwest of the Site. The WBOR flows southeast through Strafford and the northern portion of the Site near Furnace Flats. The WBOR meets the EBOR to form the Ompompanoosuc River just upstream of the Union Village Dam in Thetford, Vermont. The river then flows southeast for approximately 3.7 miles to its confluence with the Connecticut River in Norwich, Vermont.

Three primary watercourses and their associated tributaries provide drainage from the Site to the WBOR. These watercourses include Lord Brook to the southeast, Sargent Brook to the west, and Copperas Brook in the north-central portion of the Site.

Site Hydrogeology

There are three principal surface overburden units present in the area: a dense glacial basal till (resting on bedrock); sand and gravel outwash deposits above the basal till; and a thin Quaternary alluvium deposits in the drainage channels. Each unit varies in thickness and distribution. These units are shown on Figure 5. The mine and mill site is situated on the east flank of Copperas Hill, between the elevations of 850 (base of tailing pile TP-1) to 1,400 feet above sea level (at the North Open Cut). Directly underlying portions of TP-1 and TP-2 is a thin layer of gravel/sand/debris representing the pre-tailing ground surface. This thin, water-bearing horizon appears to be no more than 2 to 3 feet in thickness. Directly under this horizon is a glacial basal till sequence, measuring as much as 75 feet in thickness. The basal till rests directly on crystalline bedrock. Core samples of the till indicate that it is highly compact, dry in zones, and comprised of rock fragments in a clay/silt matrix. Within the Copperas Brook Watershed, overburden deposits are underlain by the Devonian-aged Gile Mountain Formation, the host rock of the sulfide deposit, which consists of metamorphosed black shales and graywackes, with lesser metamorphosed sandstones, calcareous shales, and diabase.

The boundaries the groundwater regime at the Site are defined by topography. Recharge to the groundwater system generally occurs in topographically elevated areas, from which groundwater flows downward to areas of lower hydraulic potential. Groundwater discharge occurs primarily in topographically lower areas (*e.g.*, ravines, gullies, and valleys) that are associated with surface water drainage features (*e.g.*, streams or rivers). The direction of groundwater flow in discharge areas is upward, with the water table typically encountered near the ground surface. Recharge areas to the groundwater regimes underlying the Copperas Brook Watershed are interpreted to generally correspond to the drainage divides for the watersheds. As an exception, the primary recharge area for the shallow and intermediate groundwater system in the Copperas Brook Watershed is interpreted to occur within and immediately east of the limits of TP-3, with additional contributions occurring from the east slope of Copperas Hill as well as from Gove Hill. Upgradient of TP-3, bedrock groundwater and surface runoff is intercepted by the North Open Cut. Excluding the effects of the North Open Cut, groundwater within the Copperas Brook Watershed is interpreted to flow downward from the mine areas towards the lower lying groundwater discharge areas along Copperas Brook.

The local groundwater flow regime underlying Copperas Brook consists of two flow systems (shallow and deep) that are capable of yielding groundwater, and an intermediate system (a low permeability layer) that separates the deep and shallow flow regimes. The shallow overburden groundwater flow system is comprised of limited saturated thicknesses of waste ore at TP-3, tailing in TP-1 and TP-2, alluvial soils (e.g., at MW-13A) and fill (e.g., at MW-19A). The deep groundwater flow system resides in fractured bedrock. Due to its low permeability, the glacial till behaves as an aquitard, limiting the rate of groundwater movement between the shallow and deep flow systems.

Groundwater equipotential contour maps developed for the shallow overburden and glacial till, as well as for the bedrock groundwater systems define flow towards and along the alignment of Copperas Brook. Based upon upward hydraulic gradients observed at all but one monitoring well cluster (*i.e.*, MW-14B/C) and artesian flow observed at three monitoring wells (*i.e.*, MW-01B, MW-11B, MW-13C), an abandoned residential bedrock well near monitoring well MW-14B/C, and a bureau of mines boring located adjacent to the WBOR, groundwater flowing away from the recharge areas is interpreted to flow upward into the overlying shallow overburden and intermediate groundwater systems before discharging to Copperas Brook. Groundwater within the tailing piles is located above the bedrock-glacial till groundwater flow regimes as a result of residual water saturation resulting from their more recent formation (*i.e.*, water-deposited fluidized tailing deposition) and hydrogeologic characteristics (moderate hydraulic conductivity and porosity, as well as the designed drainage features which are disassociated from the underlying native materials).

The Underground Workings of the Elizabeth Mine are interpreted to affect groundwater flow in areas adjacent to the workings. The Underground Workings of the mine can be conceptualized as a large tunnel, or drain, having an infinite hydraulic conductivity, with the Artesian Vent serving as the discharge outlet. The southern portion of the mine is not generally flooded but intercepts groundwater seepage through bedrock fractures and collapsed air vents and adits. Water also enters this portion of the mine as a result of direct interception of precipitation and snowmelt, and runoff from Copperas Hill. Along this area it is anticipated that the groundwater table above and immediately adjacent to the workings has been lowered to approximately the level of the workings, inducing hydraulic gradients towards the mine and groundwater seepage into the mine. The intercepted groundwater seepage is interpreted to flow into deeper and more northerly portions of the mine. Further to the north, the workings are flooded as evidenced by flowing artesian conditions at the Artesian Vent adjacent to the WBOR. The flooded portion of the mine is interpreted to behave like a confined aquifer in that pressure gradients decrease along the flooded portions of the mine in the direction of the Artesian Vent. This pressure gradient distribution also results in localized groundwater flow towards the Underground Workings, with groundwater within the Underground Workings eventually discharging through the Artesian Vent to the WBOR.

Acid Rock Drainage (ARD)

The major issue at the Elizabeth Mine is acid rock drainage. Impacts to environmental media at the Site result primarily from acid rock drainage, which occurs when sulfide mineral-bearing rock and ore are exposed to oxidizing conditions through natural weathering processes. At the Site, ARD occurs in response to the oxidation of waste rock, waste ore, tailing, exposed bedrock in open cuts or Underground Workings, slag, and roasted ore.

Acid rock drainage produces a low-pH solution (typically less than 4.0 standard units [SU]) containing elevated concentrations of iron, sulfate, and base metals present within the ore body. The geochemical reactions responsible for the oxidation of sulfide minerals, such as pyrrhotite, are driven by the availability of atmospheric oxygen and water. These geochemical reactions produce sulfuric acid, which enhances mineral weathering and promotes the mobility of certain metals native to the ore body and associated host rock, including aluminum, cadmium, cobalt, copper, iron, manganese, nickel, and zinc. In addition to the oxidation of the sulfide-bearing minerals, the cyclic formation and subsequent dissolution of evaporative metal salts on exposed waste ore and tailing also contributes ARD to site waters. Metal salts form on the surfaces of the tailing piles and waste ore piles as metal-containing acidic moisture evaporates. This process is most prominently observed at TP-3 and near the decant pond on TP-1. The metals stored in these salts are dissolved and remobilized during subsequent rainfall events. This run-off eventually is conveyed to receiving streams resulting in an increase in the metals loading above the base loading from the ongoing ARD.

Metals associated with ARD at the Site have been detected at elevated concentrations in groundwater, surface water, soil, and sediment. ARD directly affects both groundwater and surface water quality at the Site by lowering the pH and contributing elevated concentrations of metals to these media. This also occurs at the Artesian Vent (Underground Workings discharge point) and at discharges from the pit lakes, where impacted mine waters discharge directly to the ground surface as acid mine drainage (AMD). In addition, analytical data and empirical observations indicate that oxic tailing, weathered waste ore, processed ore, and byproducts generated from the smelting process (*i.e.*, slag) have been transported from the original areas of deposition by erosion and re-distributed, causing elevated concentrations of metals in the soil adjacent to the disposal areas (*e.g.*, TP-1). Some of these materials have been conveyed by overland flow resulting in elevated concentrations of metals in sediment along these Site drainage ways, including: Copperas Brook; the WBOR; unnamed tributaries leading from the South Mine, the South Open Cut, and TP-4; and Lord Brook .

A summary of the RI findings are presented below. The section is organized into the major geographic features at the Site. The main geographic features are:

- Copperas Brook Watershed and associated source areas;
- Lord Brook Watershed and associated source areas;
- Sargent Brook Watershed;
- West Branch of the Ompopanoosuc River; and
- Underground Workings

Copperas Brook Watershed

The Copperas Brook Watershed encompasses approximately 366 acres in the central portion of the Site. Copperas Brook originates from seepage at the base of TP-3 and runoff from a topographic rise located between Copperas Road and Mine Road. Copperas Brook flows north for approximately 1.2 miles, partially through a 36-inch diameter pipe to carry the flow around TP-1, before discharging into the WBOR approximately three miles east of the Village of South Strafford. The North Open Cut acts as the upstream divide for flow contribution to Copperas Brook. Drainage from uplands located west of the North Open Cut, as well as overburden and shallow bedrock groundwater from these areas (approximately 23 acres), are intercepted by the Cut and Underground Workings and do not contribute to Copperas Brook flow.

According to continual flow data collected by United States Army Corps of Engineers (USACE), the flow rate in Copperas Brook during the period between July 2003 and July 2004 ranged from less than 0.01 cubic feet per second (cfs) to more than 23 cfs, with an average apparent base flow of approximately 0.2 to 0.3 cfs.

The following mine-related features, as depicted on Figure 6, are present in the Copperas Brook watershed:

- The North Open Cut is a 960-foot-long, 250-foot-deep (at maximum point) rock cut in the western portion of the Copperas Brook Watershed. The Underground Workings are accessible from the north wall of the Cut and reportedly through the floor of the Cut in localized areas where bedrock tunnels (stoping) from the mine's 300-foot working level daylighted into the bottom of the North Open Cut.

- Waste rock pile TP-3 is a 12.5-acre waste ore pile located north and east of the North Open Cut. It consists of an estimated 233,000 cubic yards of waste ore, waste rock, and former heap leach piles from which Copperas Brook emanates. The steep topography of TP-3 and the loose, unconsolidated surface materials are prone to erosion. Waste material eroded from TP-3 can be seen in the Copperas Brook channel as far downstream as TP-2.

- The former Upper and Lower Copperas Factories are located east of TP-3 and formerly housed evaporators, crystallizers, and packaging operations during the early and mid 1800s. Currently, the copperas factories are visually identifiable as a series of stone foundations and debris scatter. The foundations, identified as the Upper and Lower Copperas Factories, formerly housed evaporators, crystallizers, and packaging operations which were in operation during the early and mid 1800s. The processing of copperas included evaporation in lead-lined vats. The Upper Copperas Factory was reportedly 267 feet long and 94 feet wide during its largest recorded configuration in 1827 and 1842. The Upper Copperas Factory foundation is located along the downgradient side of TP-3 adjacent to Copperas Brook. The Lower Copperas Factory is located further downslope from TP-3 and south of Copperas Brook. An 1870s account reported dimensions for the Lower Copperas Factory structure as approximately 120 feet long by 75 feet wide.

- Tailing dam TP-2 is located along Copperas Brook downstream of TP-3 and east of Mine Road. The feature encompasses approximately 7 acres, and contains approximately 400,000 cubic yards of WWII-era water-deposited tailing. Tailing dam TP-2 is partially vegetated with birch and beech trees, and the slopes are channeled and eroding. Copperas Brook was formerly transmitted through TP-2 within a decant structure; however failure of the decant structure, possibly during the 1970s, destroyed the piping structure and breached the tailing dam. The failure resulted in the deposition of a portion of TP-2 tailing onto the surface of TP-1 (located immediately to the north). As currently configured, Copperas Brook flows through the TP-2 tailing dam breach and onto the surface of TP-1.

- Tailing dam TP-1 is located immediately northeast of TP-2. The feature encompasses approximately 27 acres and contains approximately 2.4 million cubic yards of WWII-era tailing. Prior to implementing the TCRA the slopes of TP-1 were channeled and eroding, resulting in a depositional fan of eroded tailing north of TP-1. The majority of the tailing fan was excavated and removed during Phase 3 of the TCRA. Tailing dam TP-1 overlays a pre-WWII-era ore processing area which formerly contained smelters, roast beds, slag piles, and smaller tailing deposits. These pre-WWII-era features were buried during the TP-1 tailing deposition, with some waste materials reportedly used for TP-1 starter dam construction.

- Various buildings associated with WWII- Era Infrastructure Area are located west of TP-1. The remains of a pumping station that extracted water from the WBOR is located northwest of TP-1, on the south bank of the WBOR. Numerous former haul roads and areas of fill, both of which are often comprised of waste ore, are present in this area and extend east of Mine Road from the 1898 Adit, north for approximately 1,100 feet, and east to TP-1.

In general, analytical results indicate that soil degradation due to mining activities in the Copperas Brook Watershed are restricted to identified source areas (i.e., TP-1, TP-2, TP-3, Upper and Lower Copper Factories, and the WWII-Era Infrastructure Area) and their immediately surrounding areas.

Waste ore in TP-3 and the tailing in TP-1 and TP-2 are acid generating and contain elevated concentrations of cadmium, copper, iron, selenium, thallium, and zinc. Analytical data from eroded tailing samples collected at the toe of TP-1 are consistent with the low pH, low alkalinity, and elevated metal concentration detected in shallow groundwater samples collected from this area. Soil samples from these source areas exceed the site-specific, preliminary remediation goals (PRGs). The PRGs were based on conservative human health and ecological screening criteria. The contaminants detected above PRGs include cadmium, copper, selenium, and zinc, as well as less frequent criteria exceedences of molybdenum and thallium. Figure 7 shows the location of soil samples collection in the Copperas Brook watershed.

The findings of the RI pertaining to soils in the Copperas Brook watershed are as follows:

- Soil containing elevated lead concentrations exceeding the PRG for lead was detected in samples collected near the Copperas Factory foundations. Sampling identified lead concentrations above 400 mg/kg in an approximately 1-acre area surrounding each of the existing foundation structures. Figures 8 and 9 show the lead contamination at the Upper and Lower Copperas Factories.

- The tailing and waste rock exceed PRGs and are the source of the ARD. TP-1, TP-2, and TP-3 are within the scope of the NTCRA. Tables 1-4 list the major contaminants and the range of concentrations detected in the soil, tailing, and waste rock within and adjacent to TP-1, TP-2, and TP-3.

- Copper and selenium were detected at concentrations exceeding the PRGs in floodplain soils throughout the downstream Copperas Brook drainage. The concentrations decreased with distance from the source area. Table 5 lists the major contaminants and the range of concentrations detected in the floodplain soils below TP-1.

- Soil samples collected from the waste ore fill in the WWII-Era Infrastructure Area exceeded the PRGs for copper and selenium. Findings indicate that this material is likely a potential contributing source of ARD to surface water in Copperas Brook. Groundwater data in this area also indicates the presence of ARD. However, the small amount of groundwater present within the fill was insufficient to classify this area as being a usable aquifer. Table 6 list the major contaminants and the range of concentrations detected in the soil within the WW II-Era Infrastructure Area.

Surface water impacts related to source areas extend from the upstream origin of Copperas Brook at TP-3 to the WBOR as summarized below. Tables 7-10 lists the major contaminants and the range of concentrations detected in surface water for Copperas Brook and the TP-1 seeps. Tables 11 and 12 present the loading rates for the source areas within the Copperas Brook watershed. Figure 6 shows the surface water sampling locations.

- The dominant source of non-iron base metals is TP-3, which on average accounts for over 70 percent of the copper reaching the WBOR from Copperas Brook.

- The upper surface of tailing dams TP-1 and TP-2 also contribute a notable load of metals to Copperas Brook, although to a lesser degree and more intermittently. In general, the contribution of copper reaching the WBOR from the tailing dams represents approximately 10 percent of the total stream-transported load as assessed during post-TCRA conditions. The seepage from the toe area of TP-1 (following the TCRA, this flow emanates from the buttress drainage system) contributes significant levels of iron to Copperas Brook and constitutes the primary source of iron loading to Copperas Brook and the WBOR.

- The tailing fan located immediately north of TP-1 also contributes a significant load of base metals to Copperas Brook, although this area has been partially remediated as part of the TCRA implementation.

- Because the toe seepage rates remain relatively constant throughout the year, the seeps at the toe of TP-1 dominate the chemical characteristics of Copperas Brook during low-flow periods when the upper reaches of Copperas Brook (upstream of TP-1) exhibit negligible flow contributions. During high-flow events (i.e., storm flow events), the overall watershed, and the upper reaches in particular, exhibit acute and sudden responses to precipitation events, during which time runoff from TP-3 dominates the chemistry of Copperas Brook.

- During normal or low-flow conditions, the ARD-related metals in lower Copperas Brook surface water are present almost entirely in their dissolved phase, which is primarily due to the low pH of the Copperas Brook surface water. During high-flow storm runoff events, sampling results indicate that high sediment load entrained in the flow emanating from TP-3 also contributes a significant total-phase metal fraction to Copperas Brook. Similarly, high sediment load has been observed during high flow periods from the TCRA sediment basin (which collects TP-1 seepage flows) and from the TP-1 tailing fan area.

- The concentration of several metals, particularly, copper, iron, and zinc, in Copperas Brook greatly exceed VWQC Class B aquatic life use criteria. Copperas Brook is considered to be severely impacted based on fish and benthic community assessments.

- Surface water toxicity results indicate measurable effects associated with exposure to surface water collected from Copperas Brook. The surface water of Copperas Brook caused 100 percent mortality to test organisms even when only 10 percent of the water in the test was from Copperas Brook (with the remaining 90 percent being clean water).

- Seepage and surface water drainage from the WWII-Era Infrastructure Area exhibit ARD that contributes to the overall degradation of Copperas Brook. However these surface water discharges constitute a level of additional loading to Copperas Brook which cannot be quantified above the base loading level resulting from the TP-1, TP-2, and TP-3 source areas.

In addition to the high levels of contaminants detected in surface water, the RI also documented severe impacts to the periphyton community, the benthic macroinvertebrate community, and the fish community through field assessments of these communities.

Sediments exceed PRGs for copper and selenium throughout Copperas Brook, as well as for the drainage channel within the WWII-Era Infrastructure Area. Sediment impacts related to mine wastes extend from TP-3 to the mouth of Copperas Brook and discharge into the WBOR within an area designated as the WBOR Mixing Zone. Iron precipitation (i.e., ferricrete) and waste ore are also present within the stream channel of Copperas Brook. Sediment toxicity testing indicates significant mortality in test organisms resulting from exposure to Copperas Brook sediment. Tables 13 – 16 lists the major contaminants and the range of concentrations detected in the sediments within the Copperas Brook watershed. Figure 7 shows the location of the sediment samples collected in the Copperas Brook watershed.

Groundwater within the overburden and bedrock was evaluated as part of the RI. Contamination above groundwater PRGs, including the State of Vermont Primary Groundwater Quality Standards, was detected in localized areas beneath and immediately downgradient of TP-1, TP-2, and TP-3. Groundwater contamination associated with TP-3 is found in both the bedrock and overburden along within the waste material. The bedrock contamination extends only a limited distance beyond TP-3 and appears to end near Mine Road. The overburden and waste material groundwater contamination extends just across mine road. For TP-1 and TP-2 and the adjacent WW-II Era Infrastructure Area, the bedrock aquifer has not been impacted by the Site. Contaminated groundwater is found within the till beneath and downgradient of TP-1 and TP-2 as well as within the tailing. The entire overburden and bedrock groundwater plume associated with TP-1, TP-2, and TP-3 is within the area delineated as the Waste Management Area for the NTCRA. The groundwater sampling locations and the extent of groundwater contamination is shown on Figure 10. Tables 17 – 21 lists the major contaminants and the range of concentrations detected in the groundwater associated with TP-1, TP-2, TP-3, and the WW-II Era Infrastructure Area.

Lord Brook Watershed

The Lord Brook watershed encompasses approximately 2,270 acres in the southeastern portion of the Site (Figure 11). This watershed contains:

- The South Mine contains a 33-foot-deep, approximately 500-foot-long rock cut. The depth of the cut varies from approximately 6 to 15 feet from north to south. The volume of the South Mine Cut was determined to be approximately 9,800 cubic yards. This volume includes the Cut itself and the mining exploration pit located south of the Cut, which is approximately 11 feet at its deepest point. Sources of impacts at the South Mine include the exposed hanging and foot walls of the Cut, a pit lake contained within the northern two-thirds of the Cut, as well as waste ore piles and mine residual scatter surrounding the Cut. The pit lake volume is estimated to be approximately 400,000 gallons. During periods of high flow (*e.g.*, spring snow melt) water in the pit lake discharges to a drainage channel that eventually flows into Lord Brook. The residual waste ore and waste rock is deposited over a 1.4-acre area north, east, and west of the South Mine Cut. The waste ore and waste rock deposits were assumed to be 3 feet thick to the north, northeast and west; 6 feet thick to the east; and 10 feet thick to the south. The estimated waste ore and waste rock volume in this area is approximately 19,000 cubic yards. These waste ore and waste rock deposits encompass approximately 2.5 acres of forested land.

- The South Open Cut is a WWII-era mine feature developed in the early 1950s and is located north of the South Mine. The Cut is approximately 1,600 feet long with a maximum depth of 90 feet and was excavated into the ore body from ground surface. A haulageway was cut through the east wall of the Cut in order to facilitate material removal during the period of operation. The portion of the Cut located north of the haulageway consists of a pit lake containing approximately 3.6 million gallons of water. The pit lake discharges seasonally through the haulageway, which itself consists of surface-exposed ore and is a source of ARD. Drainage through the haulageway flows eastward across Copperas Road, along the southern flank of waste rock pile TP-4, and eventually into Lord Brook. Waste ore and waste rock at the South Open Cut are primarily located on the slope between the Cut and Copperas Road. The South Open Cut waste material covers approximately 7 acres and has been estimated to be up to 20 feet thick based upon the projected original ground surface. The total volume of waste ore and waste rock at the South Open Cut was calculated to be approximately 83,000 cubic yards. Approximately 6 acres (i.e., 87 percent) of waste ore and waste rock are located beneath a mature forest cover.

- Waste rock pile TP-4 is located east of the South Open Cut and Copperas Road and contains boulders and cobbles of wall rock and some waste ore removed as part of the surface mining at the South Open Cut. TP-4 is approximately 30 feet high and covers an area of approximately 0.8 acres. The volume of waste rock and waste ore is approximately 17,000 cubic yards.

These site features drain into two separate tributaries that converge east of TP-4 and ultimately discharge as a combined channel into Lord Brook. According to flow data collected during RI sampling events, the flow rate in Lord Brook ranged from 1.1 cfs upstream of site drainages to 4.7 cfs where Lord Brook discharges to the WBOR.

In general, analytical results indicate that soil effects related to the mine are generally restricted to the mine features (i.e., open cuts, waste piles, debris scatter) and their immediately surrounding areas. Similar to the findings in the Copperas Brook Watershed, source-area soil concentrations exceed the PRGs for cadmium, copper, manganese, selenium, and zinc. The level of contamination in soil is below PRGs for human contact but above the PRGs established for ecological receptors. Figure 11 shows the surface soil sampling locations associated with the source areas. Tables 22 – 25 lists the major contaminants and the range of concentrations detected in the soil adjacent to and within the Lord Brook watershed source areas.

Surface water is the primary exposure medium of concern. Figure 12 shows the surface water sampling locations for the unnamed tributaries to Lord Brook and a limited segment of Lord Brook just below the confluence with the unnamed tributaries. Figure 13 shows the surface water sampling locations for the entire length of Lord Brook downstream of the area covered by Figure 12. Tables 26 – 30 lists the major contaminants and the range of concentrations detected in the surface water in the unnamed tributaries that drain the Lord Brook source areas and Lord Brook. Surface water analytical data collected as part of the RI indicated the following:

- Drainage from the South Mine contain total and dissolved aluminum, cadmium, copper, zinc, and occasionally dissolved iron, lead, and nickel at concentrations that exceeded surface water quality criteria. The sources of these metals are discharges from the South Mine pit lake during periods of high flow along with runoff and groundwater seepage through the waste ore materials located along the east and north sides of the South Mine.

- Drainage from the South Open Cut and TP-4 contain concentrations of total and/or dissolved aluminum, cadmium, copper, zinc, and occasionally iron, mercury, nickel and/or lead at concentrations exceeding surface water quality criteria.

- The combined drainage from the South Mine, the South Open Cut, and TP-4 contain concentrations of total and dissolved aluminum, cadmium, copper, and zinc above surface water quality criteria.

- Total and/or dissolved aluminum, copper, and zinc periodically exceed surface water quality criteria in Lord Brook near the confluence with the mine drainage tributary.

- The benthic and fish communities sampled in the mine drainage tributary and from Lord Brook immediately downstream of the mine drainage tributary confluence fail to meet VWQS Class B aquatic life use criteria.

Surface water data in the Lord Brook Watershed indicate loading of base metals from the South Open Cut Pit Lake and waste ore piles at the South Mine and TP-4 to Lord Brook; however, the combined drainage from the South Open Cut and TP-4 is a more significant contributor of metals loading than is the drainage from the South Mine. Data suggest that TP-4 acts as a continual source of metals loading to Lord Brook, whereas the South Open Cut is a periodic source of metals loading based on the intermittent nature of the discharge from the haulageway. During periods of high flow, the South Open Cut contributes significant metals load to Lord Brook.

The metals load from the South Mine, South Open Cut, and TP-4 are decreased by geochemical attenuation and dilution along the length of unnamed tributaries that drain the South Mine/TP-4/South Open Cut. The metals load in Lord Brook appears to be influenced by geochemical attenuation (as evidenced by aluminum-containing precipitate downstream of the confluence with the source area drainage channel) and dilution, with most of the base metal load attenuating in the wetland ponds located upstream of the confluence of Lord Brook with the WBOR. Tables 31 and 32 present a loading evaluation for the Lord Brook Watershed source areas.

The evaluation of fish communities in Lord Brook indicates a significant impact to the fish community just downstream of the confluence with the unnamed tributaries. The fish population drops by 90% after the drainage from the Lord Brook source areas enters Lord Brook. The fish community recovers with distance from the contaminant stress caused by the discharge from the unnamed tributaries that drain the Lord Brook Source Areas. At the downstream end of Lord Brook, several thousand feet downstream near the confluence with the WBOR, the biological assessment did not indicate obvious impacts of Site drainage on fish assemblages.

An evaluation of benthic communities in Lord Brook indicate that stations in and along the unnamed tributaries leading from the South Mine, South Open Cut, and TP-4 to Lord Brook, and in the area of the confluence of these tributaries within Lord Brook, do not meet VWQC Class B aquatic life use criteria. Severe impairment was observed in the unnamed tributary to Lord Brook. The benthic community recovers with distance from the contaminant stress caused by the discharge from the unnamed tributaries that drain the Lord Brook Source Areas. At the downstream end of Lord Brook, several thousand feet downstream near the confluence with the WBOR, the biological assessment did not indicate obvious impacts of Site drainage on benthic community.

Sediments located downstream of the South Mine, South Open Cut, and TP-4 and within Lord Brook have been degraded by ARD primarily due to the physical transport of waste material (from the South Open Cut haulageway, the South Mine waste ore piles, and TP-4) during periods of significant runoff, and precipitation of dissolved metals from surface water due to changes in stream geochemistry. Given the high energy environment that occurs within the source area drainages during periods of high flow, sediments (including metal precipitates) may be resuspended and then transported and redeposited further downstream. Cadmium, chromium, copper, manganese, nickel, selenium, and zinc in sediment within the mine drainage tributaries of Lord Brook were detected in excess of the PRGs. The RI concluded that the effects of exposure to sediment in the unnamed tributaries leading from the South Mine, South Open Cut, and TP-4, as well as in the upper portion of Lord Brook immediately downstream of the confluence with the mine drainage tributary, may be causing adverse impacts to the benthic macroinvertebrate community, the fish community, and the woodland amphibian community. Figures 11 shows the sediment sampling locations associated with the Lord Brook source areas and the unnamed tributaries to Lord Brook that drain the source areas. Figure 13 shows the sediment sampling locations in Lord Brook. Tables 33 – 37 present the sample results for the contaminant concerns in sediment for the Lord Brook Watershed.

The bedrock is very close to the ground surface and is exposed in several areas of the upper Lord Brook Watershed near the source areas. Data from monitoring wells MW-15C and MW-16C indicate that, under current conditions, the South Open Cut pit lake does not affect groundwater quality in downgradient areas between the South Open Cut and Mine Road. Groundwater analytical data collected from temporary groundwater sampling locations indicate that TP-4 is a source of ARD to local very shallow groundwater that discharges to surface water at the toe of TP-4. There were elevated levels of copper and manganese in the groundwater. Figure 12 shows the groundwater sampling locations for the Lord Brook Source Areas.

To evaluate groundwater quality in and around the South Mine, an EPA-developed analytical model was used to assess the likelihood that infiltration through the residual waste at the South Mine would result in groundwater impacts. The analysis was based on the synthetic precipitation leaching procedure (SPLP) metal results and considered dilution effects. The evaluation concluded that the area of residual waste ore at the South Mine is not likely to pose impacts to groundwater quality.

Sargent Brook

The Sargent Brook Watershed encompasses approximately 865 acres in the western portion of the Site. The Sargent Brook watershed contains the Tyson Smelter area where ore processing activities took place during the late 1800s. Mine-related debris associated with the Tyson Smelter includes former roast beds, slag piles, roasting stalls, and building and infrastructure foundations. These site features are located adjacent to Sargent Brook at the base of a jeep trail which leads to the North and South Open Cuts. According to flow data collected during RI sampling events, the flow rate in Sargent Brook ranged from 1.5 cfs upstream of the Tyson Smelter source area to 2.3 cfs immediately upstream of Mine Road. The Sargent Brook waste areas and sampling locations are shown on Figure 14.

Cadmium, copper, selenium and zinc were detected in the soil of the Sargent Brook area. The concentrations detected were only marginally above the PRGs. Site-related constituents were not consistently detected above surface water quality criteria in Sargent Brook, and only manganese was detected at a concentration exceeding the sediment PRGs within Sargent Brook. Copper and zinc exceed surface water quality criteria at two vernal pools located downgradient of the Tyson Smelter slag pile. The RI concluded that surface water and sediment located in Sargent Brook do not present risk of harm to human populations or to populations of wildlife living in riparian areas of, or otherwise utilizing Sargent Brook. Tables 38 – 40 lists the major contaminants and the range of concentrations detected in soil, surface water, and sediment within the Sargent Brook area.

As with the South Mine, groundwater quality in and around the Sargent Brook source areas was evaluated using the EPA-developed analytical model to assess the likelihood that infiltration through the residual waste at Sargent Brook would result in groundwater impacts. The analysis was based on the SPLP metal results and considered dilution effects. The evaluation concluded that source areas within the Sargent Brook watershed are not likely to pose impacts to groundwater quality.

West Branch of the Ompompanoosuc River

Significant mine-related features along the WBOR are depicted on Figure 15 and include the the Artesian Vent, Furnace Flats (north and south), and the Copperas Brook confluence. The WBOR flows eastward where it converges with the East Branch of the Ompompanoosuc River to form the Ompompanoosuc River upstream of the Union Village Dam. The Ompompanoosuc River flows southeastward and discharges into the Connecticut River. The RI included examination of depositional areas in the Ompompanoosuc and Connecticut rivers.

Physical mine features located along the WBOR include:

- The Artesian Vent originally functioned as a vent to provide air exchange with, and utility access to, the Underground Workings. This vent now is a groundwater discharge point from the Underground Workings. Base flow from the Artesian Vent is on the order of 0.1 cfs and can at times exceed 0.4 cfs. Water discharging from the Artesian Vent flows overland a short distance before entering the WBOR.

- Furnace Flats consists of two discrete areas of mine processing operations which operated during the 1800s: Furnace Flats North (located north of the WBOR) and Furnace Flats South (located south of the WBOR). Both areas contain waste ore, slag, debris, and the foundations of former buildings/furnaces. Furnace Flats South also includes apparent roast beds. Both areas discharge surface water runoff to the WBOR, and portions of each area may become inundated by the WBOR during extreme high flow periods.

Soils in the Artesian Vent and Furnace Flats area exceed site-specific PRGs for cadmium, copper, lead, selenium, and zinc. These exceedances are due to the presence of mine residuals throughout and surrounding this feature. The RI concluded that metals in these soils are not sufficiently elevated to present a risk to humans or to populations of ecological receptors. Tables 41 and 42 lists the major contaminants and the range of concentrations detected in the soil associated with the Furnace Flats area and the artesian vent.

Groundwater quality in the Furnace Flats areas was evaluated using the EPA-developed analytical model to assess the likelihood that infiltration through the residual waste present in these areas would result in groundwater impacts. The analysis was based on the SPLP metal results and considered dilution effects. The evaluation concluded that source areas within the Furnace Flats areas of the WBOR are not likely to pose impacts to groundwater quality.

The RI evaluated surface water in the WBOR from upstream of the Site source areas extending past the confluence of the WBOR and Ompompanoosuc River and a few miles into the Connecticut River. The sample locations are shown in Figures 15 and 17 and the results for the surface water sampling are presented in Tables 43-47. Findings associated with surface water include the following:

- Water discharging to the ground surface from the Artesian Vent contains elevated concentrations of mine constituents. Metals that are not precipitated out of solution in the immediately adjacent areas are transported by overland flow a short distance to the WBOR.

- Although concentrations of aluminum, copper, iron, lead, mercury, and zinc occasionally exceed surface water quality criteria in the WBOR, water quality between Sargent Brook and Copperas Brook achieves Vermont Class B Water Quality Standards based on the results of the benthic and fish community studies.

- Metals concentrations were most consistently above surface water quality criteria in the WBOR along a 300-foot reach that extends downstream from the confluence of Copperas Brook. Along this reach of the WBOR concentrations of aluminum, cadmium, copper, iron, lead, mercury, selenium, zinc, and occasionally cyanide exceeded surface water quality criteria.

- Several metals, most frequently aluminum and copper, exceed surface water quality criteria in the WBOR downstream to the Lord Brook confluence. In many instances the exceedances at downstream locations were for total metals whereas the dissolved fraction of these metals was below criteria. The higher total fraction of these metals is likely due to metals adsorbed onto suspended particulates being transported by the stream. This fraction is not generally considered bioavailable to ecological receptors.

- Benthic community analyses in the WBOR indicate severe impacts in the WBOR Mixing Zone with a trend towards recovery with increasing distance from Copperas Brook. Partial recovery of the epifaunal benthic community is observed approximately 1.8 miles downstream of Copperas Brook (near sample stations LOC-19) where the community condition improve from 'poor' to 'fair' and partially supported Vermont Class B aquatic life use criteria. However, Vermont Class B aquatic life use criteria are not fully attained until the Ompompanoosuc River, approximately five miles downstream of the mouth of Copperas Brook (near sample station LOC-44). In addition to attaining Vermont Class B criteria, benthic community metrics at Station 44 indicate a recovery to conditions similar to the upstream reference station as community metric values exceed 70 percent of upstream reference metric values. Figure 17 shows the locations of the benthic and fish community assessments.

- Metal concentrations in algal samples were greatest in the WBOR within the area of the WBOR Mixing Zone, but decrease at downgradient locations within the WBOR.

- The results of the fish community evaluation indicate that Site-related influence to fish assemblages in the WBOR extend from the mouth of Copperas Brook to approximately 1.4 miles downstream between sample stations LOC 17 and LOC 197.

- Surface water toxicity results indicate that there was significant mortality to laboratory organisms exposed to surface water collected from Copperas Brook and from the WBOR Mixing Zone.

- Water quality in the WBOR downstream of Lord Brook was characterized by concentrations of total and dissolved aluminum, copper, iron, lead, and/or mercury that periodically exceed surface water quality criteria.

- Site-related constituents in the WBOR surface water at and immediately downstream of the confluence of Copperas Brook exceed surface water quality criteria for several metals. Exceedances of aluminum, copper, and iron associated with Copperas Brook extend downstream beyond the confluence with Lord Brook. The majority of mine constituents in the WBOR Mixing Zone reach of the WBOR are present in total fraction. These data indicate that a significant portion of metals loading to the WBOR from Copperas Brook occurs through the transport of sediment and/or colloidal material (e.g., metal precipitates) from Copperas Brook into the WBOR. These metals are attenuated by dilution and precipitation as the acidic water from Copperas Brook (pH of approximately 3.2 standard units) mixes with the alkaline water of the WBOR (pH of approximately 8.2 standard units). This change in pH results in precipitation of metals which can be integrated into the sediment bed in the WBOR Mixing Zone. These sediments may be resuspended during subsequent high flows and transported further downstream where they may be redeposited.

- Copper, selenium, and zinc in WBOR sediment exceed the PRGs. The RI concluded that the effects of exposure to sediment in the WBOR within the WBOR Mixing Zone area may be impacting the benthic macroinvertebrate community and the fish community.

The ARD from the Lord Brook watershed appear to attenuate significantly prior to the confluence of Lord Brook and the WBOR. A mass loading analysis indicates that Lord Brook is not contributing significant quantities of metals to sediments in the WBOR (i.e., less than an approximately 5 percent increase in the mass loading of base metals in sediment was observed). Sediment collected from the WBOR downstream of the Lord Brook confluence did not indicate an increase in metals concentrations from that found in sediments upstream of the confluence.

The RI concluded that the most severe area of adverse effects of exposure to surface water in the WBOR was the WBOR Mixing Zone, where exposure to surface water presents a risk of harm to the periphyton community, the benthic macroinvertebrate community, and the fish community. Exposure to surface water in the WBOR below the WBOR Mixing Zone also poses some risk to the benthic macroinvertebrate community and the fish community although these communities recover with increasing distance downstream.

Copper and selenium in WBOR sediment exceed PRGs and contribute to the exceedances of risk-based effects levels for some ecological receptors. The RI concluded that the effects of exposure to sediment in the WBOR within the WBOR Mixing Zone area may present an unacceptable risk of harm to the benthic macroinvertebrate community and the fish community. Sediment toxicity test results indicate significant mortality to laboratory organisms exposed to sediment from the mouth of Copperas Brook and the WBOR Mixing Zone extending approximately 150 feet downstream of the mouth of Copperas Brook. Tables 48 – 53 present the sediment data.

Surface water in the Ompompanoosuc River upstream of the Union Village Dam exceeds surface water quality criteria for total iron, and total and dissolved aluminum, copper, lead, and thallium. Aluminum (as total fraction) is the only element that has been detected at concentrations exceeding the surface water quality criteria below the Union Village dam. The RI concluded there was no unacceptable risk of harm to ecological receptors exposed to surface water in the Ompompanoosuc River below Union Village Dam.

In the Ompompanoosuc River, the highest concentrations and greatest number of metals exceeding sediment quality benchmarks were from the depositional area near the mouth of the Ompompanoosuc River. Concentrations of copper detected in sediment in this area are significantly higher than concentrations in sediments along the WBOR and the reach of the Ompompanoosuc River upstream of the depositional pool. Tables 52 and 53 present the sediment data for this area.

Moreover, copper, which is a significant indicator metal of ARD impacts, exceed the sediment delineation criteria in subsurface sediment to depths greater than approximately 12 inches. The relatively uniform vertical distribution of base metal concentrations with depth indicates that loading rates of base metals in this area today are similar to earlier periods, possibly including periods corresponding to mine activity. Because amorphous sulfides and organic carbon in the sediment can strongly sorb copper, these sediments may be acting as a sink for surface water-borne copper and other base metals. However, these same sediment ligands act to limit the bioavailability of these metals. Elevated concentrations of copper and other mine-related constituents including cadmium, iron, and zinc, extend into the Connecticut River and downstream along the west bank of the river in shallow sediments. The RI concluded that as these sediment-associated metals are not bioavailable and do not present an unacceptable risk of harm aquatic organisms or to populations of wildlife inhabiting or otherwise utilizing the Ompompanoosuc River.

The evaluation of fish communities in the Ompompanoosuc River did not indicate obvious impacts of Site drainage on fish assemblages.

Studies of the benthic macroinvertebrate community near the Ompompanoosuc River and Connecticut River Confluence Area conclude that there is no apparent impact to benthic communities in this area that is attributed to the Elizabeth Mine Site.

Underground Workings:

The Underground Workings encompass approximately 8,000 linear feet, extending from the north end of the South Open Cut to approximately 1,150 feet north of the Air Shaft. The Underground Workings were developed using multiple levels of excavation extending more than 975 feet below the crest elevation of Copperas Hill. The Workings are accessed at ground surface through a series of adits, shafts, and surface cuts. The Underground Workings are depicted on Figure 18.

The Underground Workings act as a groundwater sink and intercepts groundwater from both upgradient and downgradient areas. Portions of the Underground Workings that are located at higher elevations than the mine pool (typically areas to the south) transmit water intercepted by the void space as open channel flow to lower elevations, and ultimately to the mine pool, or to isolated sub-pools that may exist in discontinuous areas of excavation within the workings. The mine pool is located in the northern portion of the Underground Workings and discharges acid mine drainage to the WBOR via the Artesian Vent, upstream of Furnace Flats.

Water samples from the mine pool collected through the Artesian Vent were found to contain concentrations of total cadmium, copper, manganese, mercury, nickel, and thallium and dissolved concentrations of manganese above drinking water quality standards. Mine pool water samples collected through the South Vent indicated no elevated detections of Site-related constituents. The primary source of groundwater quality degradation within the Underground Workings is likely residual mining waste (i.e., waste ore) as well as ARD inflow to the mine pool through discharge from the unflooded portion of the Underground Workings.

2. Historic Resources

The Elizabeth Mine is an historic resource that embodies the distinctive landscape, engineering, and architectural resources that are characteristic of an early nineteenth- to mid-twentieth-century American metal mining and processing site. It constitutes one of the largest and most intact historic mining sites in New England and includes the only intact cluster of hard-rock mining buildings in the region. The Elizabeth Mine was the site of a major nineteenth century U.S. copperas manufacturing plant and is associated with successful patents for copperas production. It is also associated with a number of significant commercial, scientific, and political figures, including Isaac Tyson, Jr., a Baltimore, Maryland-based chemical and mining figure who was recently inducted into the American Institute of Mining, Metallurgical and Petroleum Engineers' (AIME) Mining Hall of Fame. EPA has determined the Elizabeth Mine Site to be eligible for listing on the National Register of Historic Places. As part of the RI, EPA has documented the historic resources at the Site in several reports that are contained in the Administrative Record for the Site. The area of potential effect (APE) for the TCRA, NTCRA, and Remedial Action is shown on Figure 4.

3. Conceptual Site Model

The Conceptual Site Model (CSM) is a diagram of the sources of contamination, release mechanisms and exposure pathways to receptors for the groundwater, as well as other site-specific factors. The CSM is a three-dimensional "picture" of Site conditions that illustrates contaminant sources, release mechanisms, exposure pathways, migration routes and potential human and ecological receptors. It documents current and potential future Site conditions and shows what is known about human and environmental exposure through contaminant release and migration to potential receptors. Site receptors include individuals and organisms that may come into contact with contaminated soils; ingest contaminated soil; consume the groundwater; come into contact with or ingest surface water, sediment interstitial (pore) water or sediment; or consume organisms that have accumulated contamination. The risk assessment and response action for the Site are based on this CSM as described below. Figure 19 shows the conceptual model developed for the Site Baseline Ecological Risk Assessment.

Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur. The manner in which principal threats are addressed generally will determine whether the statutory preference for treatment as a principal element is satisfied. Wastes generally considered to be principal threats are liquid, mobile and/or highly-toxic source material. The only principal threat waste at the Site is the lead contaminated soil at the Upper and Lower Copperas Factories. This principal threat waste will be addressed as part of the remedial action.

Low-level threat wastes are those source materials that generally can be reliably contained and that would present only a low risk in the event of exposure. Wastes that are generally considered to be low-level threat wastes include non-mobile contaminated source material of low to moderate toxicity, surface soil containing chemicals of concern that are relatively immobile in air or ground water, low leachability contaminants, or low toxicity source material. The majority of the wastes at the Site are low-level threat wastes that are causing ARD. ARD and erosion of material from the waste piles are the primary mechanism by which contaminants are being transported from the Site and causing the degradation of the surface water, sediment, and groundwater. The ARD also has direct impacts on the biota in the Site area.

F. CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

The most recent and current land use of the Site area is low density residential, forest, and exposed waste piles. Substantial activity for most of the Site ceased when the Elizabeth Mine closed in 1958. The current use is also restricted as a result of the cleanup actions. The land use of the area surrounding the Site is mixed low density residential and recreational use of the forested area. Portions of the Site are posted No Trespassing by the private landowners. EPA has restricted access to areas that have ongoing construction work. EPA provided the Town of Strafford with a Redevelopment Initiative Grant, the outcome of which was the Reuse Plan.

The future land use assumptions for the Site and surrounding areas are based on the reuse assumptions developed as part of the Reuse Plan. The potential beneficial future use of the Site is presented in the Reuse Plan. It should be noted that all of the land is currently private property and that the current land-owners have not expressed a strong interest in re-use. Also, the Site is a historic property that is considered eligible for the National Register of Historic Places. The surface water at the Site is classified as a Class B water. The small drainages that include Copperas Brook and the tributaries to Lord Brook are unlikely to offer substantial human use benefits after achieving cleanup standards, although they eventually would be restored to a condition that would support cold-water fish species (such as trout). A summary of the Site use assumptions is presented in Table 54.

Community and stakeholder input was sought and incorporated through active outreach during the RI/FS. EPA held numerous meetings, held private discussions with local residents, landowners, and Town officials and solicited the views of the Potentially Responsible Partoes (PRPs). As noted above, the local community was provided an EPA Redevelopment Initiative Grant.

G. SUMMARY OF SITE RISKS

A baseline risk assessment was performed to estimate the probability and magnitude of potential adverse human health and environmental effects from exposure to contaminants associated with the Site assuming no remedial action was taken. The results of the human health risk assessment provide the basis for taking action and identify the contaminants and exposure pathways that need to be addressed by the remedial action. The human health and ecological risk assessments followed a four step process: (1) hazard identification, which identified those hazardous substances which, given the specifics of the Site, were of significant concern; (2) exposure assessment, which identified actual or potential exposure pathways, characterized the potentially exposed populations and determined the extent of possible exposure; (3) effects assessment, which considered the types and magnitude of adverse effects associated with exposure to hazardous substances; and (4) risk characterization and uncertainty analysis, which integrated the three earlier steps to summarize the potential and actual risks posed by hazardous substances at the Site, including carcinogenic and non-carcinogenic risks and a discussion of the risk at background levels of contamination and the uncertainty in the risk estimates.

A summary of those aspects of the human health risk assessment that support the need for remedial action is discussed below, followed by a summary of the environmental risk assessment.

1. Human Health Risk Assessment

Sixteen of the more than 28 chemicals detected at the site were selected for evaluation in the human health risk assessment as chemicals of potential concern. The chemicals of potential concern were selected to represent potential site related hazards based on toxicity, concentration, frequency of detection, and mobility and persistence in the environment and can be found in Tables 2.1 – 2.91 of the Human Health Risk Assessment of the RI. From this, a subset of the chemicals were identified in the RI and Feasibility Study as presenting a significant current or future risk and are referred to as the chemicals of concern in this ROD and summarized in Tables 55 – 58, which are attached to this ROD. This Table contains the exposure point concentrations used to evaluate the reasonable maximum exposure scenario (RME) in the baseline risk assessment for the chemicals of concern. Estimates of average or central tendency exposure concentrations for the chemicals of concern and all chemicals of potential concern can be found 3.1 – 3.91 of the Human Health Risk Assessment of the RI.

Potential human health effects associated with exposure to the chemicals of potential concern were estimated quantitatively or qualitatively through the development of several hypothetical exposure pathways. These pathways were developed to reflect the potential for exposure to hazardous substances based on the present uses, potential future uses, and location of the Site. The Site area is a mix of low density residential and forested land. The Site itself consists of mostly undeveloped waste piles surrounded by forest. There is one residence within the Site. Drinking water for the area surrounding the Site is obtained from groundwater, primarily the bedrock aquifer. Most of the surface water in the vicinity of the Site is too shallow for swimming. However, the South Open Cut pit lake has been used by trespassers for swimming. Future land use in the Site area is expected to remain similar to current. Access to the South

Open Cut pit lake will be permanently prohibited in order to protect components of the remedy. It is likely that residential and recreational activity will further encroach upon the Site in the future.

The following is a brief summary of just the exposure pathways that were found to present a significant risk. A more thorough description of all exposure pathways evaluated in the risk assessment including estimates for an average exposure scenario, can be found in Section 3 of the Human Health Risk Assessment in the RI.

For groundwater, it was assumed that a future resident could consume contaminated groundwater at the Site. Three separate areas were evaluated for exposure due to the special distribution of contamination at the Site. The water contained within the Underground Workings of the mine, the water within and adjacent to TP-3, and the water within and adjacent to TP-1/TP-2 were independently evaluated. Both an adult and child scenario was developed for consideration in the risk assessment. For the adult, it was assumed that a 70 kg adult would consumer 2 liters per day of contaminated water for 350 days per year over a 24 year period. For the child, it was assumed that a 15 kg child would consume 1.5 liters per day of contaminated water for 350 days per year over a six year period.

For soil, lead was the only contaminant of concern. EPA's Integrated Exposure and Uptake Biokinetic (IEUBK) model was used to assess the potential risk to children who may be exposed to lead at the Site. Lead was only detected at a concentration of concern at the location of the former Copperas Factories, which had used lead lined vats to process the copperas. The factories closed during the 1880's, and the remnants of the factories are considered a lead "hot spot".

Excess lifetime cancer risks were determined for each exposure pathway by multiplying a daily intake level with the chemical specific cancer potency factor. Cancer potency factors have been developed by EPA from epidemiological or animal studies to reflect a conservative "upper bound" of the risk posed by potentially carcinogenic compounds. That is, the true risk is unlikely to be greater than the risk predicted. The resulting risk estimates are expressed in scientific notation as a probability (e.g. 1×10^{-6} for 1/1,000,000) and indicate (using this example), that an average individual is not likely to have greater that a one in a million chance of developing cancer over 70 years as a result of site-related exposure (as defined) to the compound at the stated concentration. All risks estimated represent an "excess lifetime cancer risk" - or the additional cancer risk on top of that which we all face from other causes such as cigarette smoke or exposure to ultraviolet radiation from the sun. The chance of an individual developing cancer from all other (non-site related) causes has been estimated to be as high as one in three. EPA's generally acceptable risk range for site related exposure is 10^{-4} to 10^{-6}. Current EPA practice considers carcinogenic risks to be additive when assessing exposure to a mixture of hazardous substances. A summary of the cancer toxicity data relevant to the chemicals of concern is presented in Table 59.

In assessing the potential for adverse effects other than cancer, a hazard quotient (HQ) is calculated by dividing the daily intake level by the reference dose (RfD) or other suitable benchmark. Reference doses have been developed by EPA and they represent a level to which an individual may be exposed that is not expected to result in any deleterious effect. RfDs are derived from epidemiological or animal studies and incorporate uncertainty factors to help ensure that adverse health effects will not occur. A HQ $\leq$ 1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic noncarcinogenic effects from that chemical are unlikely. The Hazard Index (HI) is generated by adding the HQs for all chemical(s) of concern that affect the same target organ (e.g. liver) within or across those media to which the same individual may reasonably be exposed. A HI $\leq$ 1 indicates that toxic noncarcinogenic effects are unlikely. A summary of the noncarcinogenic toxicity data relevant to the chemicals of concern is presented in Table 60.

Tables 61 -68 depict the carcinogenic and non-carcinogenic risk summary for the chemicals of concern in groundwater evaluated to reflect potential future ingestion of contaminated groundwater corresponding to the reasonable maximum exposure (RME) scenario. The residential wells in the area of the Site that are currently in use do not contain site specific contamination, although one residence that is no longer in use has been impacted by the Site and does contain levels of cadmium, copper, and manganese above federal and state standards. Only those exposure pathways deemed relevant to the remedy being proposed are presented in this ROD. Readers are referred to Section 5 and Tables 7.1 – 7.26 of the HHRA in the RI for a more comprehensive risk summary of all exposure pathways evaluated for all chemicals of potential concern and for estimates of the central tendency risk.

The only pathway for which a quantitative risk assessment revealed a potential threat was the future potential ingestion of groundwater from three areas of the Site: Underground Workings, beneath and adjacent to TP-1/TP-2, and beneath and adjacent to TP-3. The estimated cancer risk from ingestion of arsenic was higher than the upper bound of the EPA acceptable risk range (1 x 10^{-4}). Estimated non-carcinogenic risk above a Hazard Quotient of 1 was estimated for: arsenic, barium, cadmium, manganese, mercury, nickel, thallium vanadium, and zinc. In addition, the following contaminants were detected above federal Maximum Contaminant Levels (MCLs) or State of Vermont Primary Groundwater Quality Standards: arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, nitrate/nitrite, selenium, thallium, vanadium, and zinc.

The Integrated Exposure and Uptake Biokinetic (IEUBK) lead model was used to evaluate the hazard potential posed by exposure of young children less than 7 years of age as the most sensitive receptor group. It is EPA policy to protect 95% of the sensitive population against blood lead levels in excess of 10 ug/dl blood. The IEUBK model used was IEUBK win v1.0 build 263: December 2005. The IEUBK model was run to assess exposure to contaminated soil using default assumptions for ingestion and concentration inputs for drinking water, air, and diet. Soil and dust ingestion rates were default values, however, the soil concentration was based on the arithmetic average and dust was assumed to be 70% of the soil concentration. For groundwater, site specific groundwater concentrations from select wells were used. The outcome of the model revealed that child exposure to the lead at the Copperas Factories would result in 99.3% of the child receptors ages 0-7 years old having a blood lead concentration above10 ug/dl. All other areas of the Site were determined not to represent a threat to individuals who may come in contact with the lead in soil. For groundwater, site specific soil and groundwater concentrations were used along with the model default parameters for all other inputs. Future consumption of the contaminated groundwater (lead concentration 261 ug/l) within and adjacent to TP-3 would result in 54% of the child receptors ages 0-7 years old having a blood lead concentration above10 ug/dl.

Future consumption of the contaminated groundwater (lead concentration 261 ug/l) within and adjacent to TP-1/TP-2 would result in 50% of the child receptors ages 0-7 years old would have a blood lead concentration above10 ug/dl. The HHRA also evaluated a recreational and subsistence fish consumption pathway. Based on the average fish concentration and assuming that 100% of the dietary intake of meat was fish, the IEUBK model estimated that 6.9% of the child receptors ages 0-7 years old having a blood lead concentration above10 ug/dl. Although this pathway was evaluated, there is not sufficient biomass for the fishery to sustain subsistence consumption of fish, therefore, it is not considered a significant threat. In addition, the elevated levels of lead were detected upstream of the Site.

2. Ecological Risk Assessment

The objective of the ecological risk assessment was to identify and estimate the potential ecological impacts associated with the COCs at the Site. In 2003, a Screening Level Ecological Risk Assessment (SLERA) was prepared to determine if Site contaminants were present at concentrations that could cause adverse impacts to ecological receptors in the Site area. The SLERA documented that contaminants were present at concentrations that could harm ecological receptors. A Baseline Ecological Risk Assessment (BERA) was then prepared to more fully evaluate the potential threats to ecological receptors using, whenever possible, multiple lines of evidence. The technical guidance for performance of the ecological risk assessment comes primarily from the following sources: Framework for Ecological Risk Assessment, Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments; and Guidelines for Ecological Risk Assessment.

A. Identification of Contaminants of Concern

Contaminants of Potential Concern (COPCs) were selected for each identified exposure area grouping within the surface water, sediment, or soil media. The COPC selection process consisted of a comparison of maximum detected analyte concentrations to conservative screening-level benchmarks and is summarized in Appendix B of the BERA. Tables B1 – 1 through B1-19 in Appendix B of the BERA summarize the COPC screening process from the SLERA. Tables B2-1 through B2-3 of Appendix B of the BERA present a refinement of the COPC list using data across the entire Site area, including data collected since the completion of the SLERA in 2003. The approach for selecting screening values employed the following screening criteria:

• Surface Water: National Recommended Water Quality Criteria (NRWQC) were the primary source of screening criteria. If NRWQC were not available, then the following criteria were used, in order of precedence: Vermont Water Quality Standards (VtWQS), Ecotox threshold values, EPA Region V EPA Ecological Screening Levels ESLs, and NOAA Screening Quick Reference Tables (SQuiRT).
• Sediment: Revised USEPA Region V ESLs were the primary screening criteria for evaluating sediment. If ESLs were not available then the following criteria were used, in order of precedence: sediment quality criteria derived by Oak Ridge National Laboratory, SQuiRT, Ontario Ministry of the Environment, and other available sources.
• Soil: Revised USEPA Region V ESLs were the primary screening criteria for evaluating soils. If Region V ESLs were not available then Oak Ridge National Laboratory Toxicity

Benchmarks were used.

Seventeen metals and cyanide were identified as COPCs in surface water. Eighteen metals were identified as COPCs in sediment. Twenty metals and cyanide were identified as COPCs in soil. In addition to comparing the concentrations of contaminants in Site media to toxicological benchmarks and toxicological reference values (TRVs), several site-specific studies were conducted to provide alternative lines of evidence for evaluating risk. These studies included:

- A habitat survey, including characterization of vegetative cover type and wetlands on Site;
- Assessment of the periphyton, benthic, fish, and terrestrial plant communities;
- Analysis of fish, plant and invertebrate tissue;
- Surface water bioassays; and
- Sediment bioassays.

The summary statistics for the COPCs are presented in Tables 69-79 attached to the ROD.

B. Exposure Assessment

Animals and plants that occur in or adjacent to the Site waste areas, Copperas Brook, Lord Brook, unnamed tributary to Lord Brook, West Branch of the Ompompanoosuc River, including invertebrates, fish, amphibians, birds, and mammals, could be exposed to contaminants through contact with soil, sediment and surface water as well as through prey consumption. Species representing various trophic levels were selected as representative receptor species to evaluate the assessment endpoints discussed in Section 3.7 and 3.10 of the BERA. The selected species are intended to be representative of other species at the same trophic level that share similar specific life history characteristics. These groups of species are generally referred to as guilds. By evaluating a representative member of a guild and by accounting for the predominant guilds, the uncertainty associated with missing an important species group or pathway is reduced. The following section describes the pathways by which the representative receptor species or taxa could be exposed to contaminants that are within the study area. Ecological receptors may be exposed to site-related contaminants through a variety of exposure pathways. A complete exposure pathway involves a potential for contact between a given receptor and contamination either through direct exposure to an abiotic medium or indirectly through prey consumption. Pathways are evaluated by considering information on contaminant fate and transport, ecosystems potentially affected, and the magnitude and extent of contamination.

The potential routes of exposure are the means by which chemicals are transferred from a contaminated medium to ecological receptors. The routes by which ecological receptors may be exposed to COPCs in the Elizabeth Mine area include:

- Periphyton – direct contact with sediment and surface water;
- Benthic macroinvertebrates – ingestion and direct contact with sediment or surface water;
- Fish – ingestion and direct contact with sediment and surface water;

- Terrestrial plants – direct contact with soil or sediment;
- Soil community – ingestion and direct contact with soil or sediment;
- Amphibians – direct contact with surface water and soil or sediment; and
- Birds and mammals – ingestion of soil or sediment, surface water, and food.

These potential exposure pathways are illustrated in the Conceptual Site Model (CSM) which is shown on Figure 19. Table 80, which is attached to the ROD, summarizes the assessment endpoints and specific risk questions were used to organize and focus the BERA along with measurement endpoints that were used to support the evaluation. Section 3.9 and 3.10 of the BERA discuss the CSM, assessment endpoints, risk questions, and measurement endpoints.

C. Ecological Effects Assessment

The Effects Analysis is a qualitative and quantitative description of the relationship between the chemical concentration or dose and the nature of possible effects elicited in exposed receptors, populations, or ecological communities. The effects data that were used to evaluate ecological risks resulting from chemical exposures were of four types: (1) Generic criteria, i.e., NRWQC for surface water and PECs for sediment, (2) literature-derived single-chemical toxicity data, (3) site-specific ambient media toxicity tests (e.g. surface water and sediment toxicity tests), and (4) site-specific community assessments.

These effects data were accorded the following weight of evidence [numbered according to relative significance, with 1) having greater weight than 3)]:

1) Comparison of observed effects in the receptor group community characteristics in waterbodies in and adjacent to the Site to receptor group community characteristics from reference areas;
2) The results of bioassays conducted using standardized toxicity tests with sediments and surface water samples on and adjacent to the Site and surrogate test organisms;
3) Comparison of site-specific media concentrations and/or estimated ingested contaminant dose estimates (the latter for wildlife) to effects levels (TRVs) for the various receptors of concern (ROCs).

Toxicological reference values for birds and mammals were selected from studies evaluating chronic effects on measurement endpoints that could have adverse effects on reproduction, development, growth, or, if no more relevant studies were available, mortality. Short-term tests were not considered unless they occurred during development and no longer-term data were available, and single dose tests were not considered because there was no way of estimating where the data fit on a dose-response curve. The number of studies evaluated reflects those studies that met these criteria. Because a large number of tests were evaluated, only the data from the selected test is discussed in detail. When a single test was judged to be superior to all others, this test was selected for TRV development, but when several studies were judged to be of similar quality, the geometric mean for the study endpoints was selected for the TRV. Both no-observed-adverse-effects-level (NOAEL) and low-observed-adverse- effects-level (LOAEL)-based TRVs were derived. Both endpoints were usually derived from the same study, but in cases where this was not possible or a different study provided superior information, separate studies were used as the basis for the NOAEL and LOAEL. For other receptors only no-observed-effects-concentration benchmarks were used. Section 5 of the BERA describes the effects analysis in detail.

D. Ecological Risk Characterization

Risk Characterization is the final phase of the BERA. In the Risk Characterization the information from the effects and exposure analyses was used to determine a probability of adverse effects to ROCs and discuss the strengths, weaknesses, and assumptions in the BERA. Risk estimates (or Hazard Quotients) were developed for each assessment endpoint based upon comparison of site-specific media concentrations and/or estimated ingested contaminant dose estimates (the latter for wildlife) to effects levels (generic criteria, benchmarks and TRVs) for the various ROCs. Finally, risk was characterized for each assessment endpoint by integrating the risk estimate with the results of other lines of evidence. Section 6 of the BERA contains the Risk Characterization.

It was concluded that elements of the following ecological receptor groups were experiencing, or at risk of experiencing, adverse effects that impact the biological integrity of their community in certain portions of the Site area:

- Periphyton
- Benthic Macroinvertebrates
- Fish
- Amphibians

Tables 81 and 82, which are attached to the ROD, present the hazard quotients for surface water and sediment for aquatic receptors. For the remaining ecological receptor groups the magnitude of the potential adverse impacts to ecological receptors and/or the extent of the impacts outside of the three major source areas (TP- 1, TP-2, and TP-3) resulted in a determination that significant adverse effects to the biological integrity of these receptor communities (or the individuals members of the bat community) were not likely to occur.

The exposure areas of the Site where the unacceptable impacts have been identified are presented below.

Lord Brook Watershed

Surface water presently within and discharging from the three source areas within the Lord Brook Watershed (South Open Cut, South Mine, and TP-4) is causing adverse effects to the periphyton, benthic macroinvertebrate, fish, and amphibian communities. The impairment is most severe in the unnamed tributaries that drain the Lord Brook source areas and in the initial portion of Lord Brook below the confluence with this tributary. There is some uncertainty as to the extent of Lord Brook that is impaired. Based on fish and benthic community assessments 0.2 miles from the confluence of Lord Brook with the WBOR (which is 3.1 miles from the confluence of Lord Brook with the tributaries from the source area), the impacts do not extend the entire length of Lord Brook since this location was found to have fully functioning fish and benthic communities and the surface water chemistry also suggest that no impacts should occur this far downstream. It is estimated that the impacts to Lord Brook may extend about 1 mile downstream to a wetland area.

Copperas Brook Watershed

Surface water discharging from the source areas (TP-1, TP-2 and TP-3) is also causing an adverse effect to the periphyton, benthic macroinvertebrate, fish, and amphibian communities. Severe impacts for these receptors extend for the entire length of Copperas Brook and for the initial few hundred yards of the WBOR Mixing Zone. The impacts in the WBOR decrease with distance from Copperas Brook. Impacts to the fish community appear to extend for about 1 mile below the confluence between Copperas Brook and the WBOR. Impacts to the benthic macroinvertebrate community reduce substantially in the first mile below the confluence (similar to the fish community) between Copperas Brook and the WBOR. However, the benthic community does not fully comply with Vermont Class B metrics or to levels comparable to the upstream reference for about 5 miles from the same confluence. In addition, sediments within Copperas Brook and the first several hundred feet of the WBOR Mixing Zone are also associated with significant adverse impacts to ecological receptors.

Most exposure pathways in other areas on Site presented little or no evidence of adverse impacts, and were not considered further in the Feasibility Study. The BERA concluded that the potential for adverse effects in these areas was low and not substantial enough to present a risk of adverse alterations, at the population or community level, on the ecological receptors inhabiting or utilizing these areas.

3. Overall Risk Assessment Conclusion--Basis for Response Action.

The baseline Human Health Risk Assessment revealed that an unacceptable human health risk would exist as a result of ingestion and direct contact with lead contaminated soil in the area of the Upper and Lower Copperas Factories. Also there is an unacceptable human health risk from ingestion of groundwater contaminated with Site COCs, under and adjacent to TP-1, TP-2, and TP-3 and from the Underground Workings, when that water was used for drinking water by a future resident. The BERA revealed that unacceptable risk would exist for benthic organisms, fish communities, amphibians, and periphyton from the discharge of acid rock and acid mine drainage from the waste areas. As such, actual or threatened releases of hazardous substances from this Site, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment. Figure 20 identifies the areas that present a threat to Human Health and Figure 21 identifies the areas that present a threat to ecological receptors.

H. REMEDIATION OBJECTIVES

Based on preliminary information relating to the types of contaminants, environmental media of concern and potential exposure pathways, response action objectives (RAOs) were developed to aid in the development and screening of alternatives. These RAOs were developed to mitigate, restore and/or prevent existing and future potential threats to human health and the environment.

The RAOs for the selected remedy for the Site are:

Upper and Lower Copperas Factories:

- Prevent direct contact or incidental ingestion of soil containing lead above 400 mg/kg.

Groundwater (Underground Workings and beneath/adjacent to TP-1, TP-2, and TP-3):

- Prevent ingestion of groundwater containing levels of site specific contamination in excess of federal Safe Drinking Water Act maximum contaminant levels (MCls), non-zero maximum contaminant levels goals (MCLGs), or Vermont Primary Groundwater Quality Standards, whichever is lower or, in their absence, a level that is set at a non cancer hazard quotient of 1 or an excess cancer risk of 1×10^{-6} or less.

For Lord Brook Watershed Source Areas:

- Achieve federal Clean Water Act and Vermont Water Quality Standards for a Class B surface water in Lord Brook and the tributaries of the Lord Brook that drain the South Mine, South Open Cut, and TP-4, by reducing or preventing the release of ARD containing metal concentrations above surface water cleanup levels from these areas.

Sediments (Lower Copperas Brook, WBOR Mixing Zone, and unnamed tributaries to Lord Brook):

- Reduce sediment concentrations to levels that are no longer acutely toxic and allow the surface water to achieve federal Clean Water Act and Vermont Water Quality Standards for a Class B surface water in Copperas Brook, the WBOR, the unnamed tributaries to Lord Brook, and Lord Brook.

WWII –Era Infrastructure Area:

- Control ARD run-off from exposed waste material to allow Copperas Brook and the WBOR to achieve federal Clean Water Act and Vermont Water Quality Standards for a Class B surface water.

I. DEVELOPMENT AND SCREENING OF ALTERNATIVES

1. Statutory Requirements/Response Objectives

Under its legal authorities, EPA's primary responsibility at Superfund sites is to undertake remedial actions that are protective of human health and the environment. In addition, Section 121 of CERCLA establishes several other statutory requirements and preferences, including: a requirement that EPA's remedial action, when complete, must comply with all federal and more stringent state environmental and facility siting standards, requirements, criteria or limitations, unless a waiver is invoked; a requirement that EPA select a remedial action that is cost-effective and that utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and a preference for remedies in which treatment which permanently and significantly reduces the volume, toxicity or mobility of the hazardous substances is a principal element over remedies not involving such treatment. Response alternatives were developed to be consistent with these Congressional mandates.

2. Technology and Alternative Development and Screening

CERCLA and the NCP set forth the process by which remedial actions are evaluated and selected. In accordance with these requirements, a range of alternatives were developed for the Site.

With respect to the response action, the RI/FS developed a limited number of remedial alternatives that attain Site cleanup levels within different time frames using different technologies, as well as a no-action alternative.

As discussed in Section 4 of the FS, groundwater treatment technology options were identified, assessed and screened based on implementability, effectiveness and cost. Section 5 of the FS Report presented the remedial alternatives developed by combining the technologies identified in the previous screening process in the categories identified in Section 300.430(e)(3) of the NCP. The purpose of the initial screening was to narrow the number of potential remedial actions for further detailed analysis while preserving a range of options. Each alternative was then evaluated in detail in Section 6 of the FS.

J. DESCRIPTION OF ALTERNATIVES

This Section provides a narrative summary of each alternative evaluated. Each of the alternatives is summarized below. A more complete, detailed presentation of each alternative can be found in Sections 4-8 of the FS.

Five areas of the Site were evaluated independently in the FS. One cleanup alternative from each area was then selected as the proposed final remedy for the Elizabeth Mine Superfund Site. The five areas are:

- Lord Brook Source Areas (LBSA) – Four alternatives were evaluated in detail for this area.
- Copperas Factories (CF) – Three alternatives were evaluated in detail for this area.
- Sediments of Lower Copperas Brook, Mixing Zone of the WBOR, and unnamed tributaries to Lord Brook (SED) – Three alternatives were evaluated in detail for this area.
- WWII-Era Infrastructure Area (IA) – Four alternatives were evaluated in detail for this area.
- Site Wide Groundwater and Land Use Restrictions (SW) –Two alternatives were evaluated in detail for this area.

A brief summary of the alternatives retained for detailed analysis within each area is presented in the following section. The costs for each alternative include the estimated capital costs, the estimated annual operation and maintenance (O & M) cost, and the present value of the combined capital and maintenance costs based on a 30 year time period and 7% discount rate. Annual operation and maintenance costs are for each alternative independently and do not account for the possibility that the O & M for several areas could be performed at the same time and assumes that all work is contracted. For a fund lead Site, the State of Vermont is required to accept responsibility for performing 100% of the O & M. The actual O & M costs may be substantially lower than the estimate in the FS if the State of Vermont were to use staff and other internal resources to perform the necessary activities.

Lord Brook Source Areas (LBSA)

LSBA 1 – No Action. This alternative is required by statute as a baseline to identify the consequence of taking no action at the Site. For this alternative, the ongoing discharge of acid rock drainage and the associated impacts to the unnamed tributary to Lord Brook and to Lord Brook would continue indefinitely. No monitoring or other actions would be taken to protect public health or the environment. There are no capital or long term costs associated with this alternative, except for the cost of conducting a review of the remedy, at a minimum, every five years. The estimated cost for each five year review is $15,000. The present value of the five year reviews is $32,450.

LBSA 2B - Collection and passive treatment of discharge from source areas. This alternative includes the collection of the surface water discharge from the South Mine, TP-4, and the South Open Cut. The flow would be collected in detention basins to retain storm water and spring melt until the storage capacity is reached. Water would be treated with a passive technology such as Sulfate Reducing Bacteria (SRB) bioreactors or a contact media reactor (Bauxsol, appatite). The actual technology would be determined during design studies. The water would be treated to meet discharge standards based on Vermont Water Quality Standards. The treated effluent would discharge to the unnamed tributaries to Lord Brook. Some impacts to wetlands in this area would occur in order to install the detention basins and treatment system. The historic features in this area would remain intact. Long-term monitoring of the effluent and receiving water would be necessary to evaluate the effectiveness of the cleanup. A review of the cleanup action would be performed every five years to ensure that the cleanup is protective of human health and the environment. Institutional controls (land use restrictions) would be put in place to protect the remedy and prevent activities that could cause the exposure and weathering of waste rock. Estimated capital cost: $3.2 million. Estimated annual operation and maintenance costs: $96,550. Present value of capital and maintenance costs: $4.5 million.

LBSA 3 – Complete consolidation of surficial mine waste and elimination of impacted surface water discharges. The objective of this alternative is to achieve the restoration of the surface water quality without a treatment system and to minimize long-term maintenance. The South Open Cut would be filled with waste material from TP-4, South Mine, and possibly other areas of the Site (such as TP-3). The South Open Cut has an estimated capacity of 142,000 cubic yards. TP-4, estimated at 17,000 cubic yards, would be completely removed and placed within the South Open Cut. The South Mine waste rock would be graded, consolidated, or removed to minimize the discharge of acid rock drainage from that area. An estimated 19,000 cubic yards of

South Mine waste rock may be placed in the South Open Cut. A vegetative soil cover would be placed over the exposed waste in the South Open Cut and South Mine. The cover would be graded to promote surface water run-off and limit infiltration. Design studies will determine if amendments, such as a source of alkalinity or organic material, to the waste are necessary. Some impacts to wetlands in this area will occur in order to install the access roads to relocate the waste and fill the cuts. Several small wetlands that are currently receiving acid drainage would be eliminated due to the cleanup efforts. The South Open Cut and South Mine pit lakes would be eliminated as aquatic resources. Both the South Open Cut and TP-4 would be eliminated as historic features. Major changes to the South Mine historic features would occur. If possible, portions of the South Mine not causing acid rock drainage would be left exposed. Long-term monitoring of the downstream water quality and aquatic resources would be necessary to evaluate the effectiveness of the cleanup. A review of the cleanup action would be performed every five years to ensure that the cleanup is protective of human health and the environment. Institutional controls (land use restrictions) would be put in place to protect the remedy and prevent activities that could cause the exposure and weathering of waste rock. Estimated capital cost: $7.1 million. Estimated annual operation and maintenance costs: $23,000. Present value of capital and maintenance costs: $7.4 million.

LBSA 4 - Full consolidation of TP-4 and partial consolidation of South Mine and South Open Cut mine wastes with diversion of surface water and discharge of residual water to surface water or groundwater – Preferred Alternative. This alternative includes the consolidation and covering of waste and exposed rock causing the majority of the acid rock drainage and the diversion of water around the South Mine and South Open Cut. The South Open Cut outlet would be dammed to increase the depth of the pit lake in order to serve as a storage basin to allow for a controlled release of water from the pit lake and to reduce acid rock discharge by inundating currently exposed acid generating rock faces in the Cut. The South Open Cut has an estimated storage capacity of 6 acre feet. The dry portion of the South Open Cut would be filled. TP-4, estimated at 17,000 cubic yards, would be completely removed and placed within the dry portion of the South Open Cut. The South Mine waste rock that is located immediately down gradient of the South Mine pit lake would also be removed to minimize the discharge of acid rock drainage from that area and placed in the dry portion of the South Open Cut. Up to 19,000 cubic yards of South Mine waste rock may be placed in the South Open Cut. However, it is likely that a much lower volume may be re-located to achieve the cleanup objectives. Once the waste rock is removed, the South Mine pit lake would be re-established as serve as a detention basin in the surface water management design for the area. A vegetative soil cover would be placed over the exposed waste in the South Open Cut and South Mine. The cover would be graded to promote surface water run-off and limit infiltration. Design studies will determine if amendments, such as a source of alkalinity or organic material, to the waste are necessary. The South Open Cut outlet would be controlled by installing a dam and outlet pipe. A discharge of approximately 2 gallons per minute would be required to prevent the South Open Cut from overflowing the dam. In addition, the annual average flow from the South Mine after installing the surface water diversion would be 5 gallons per minute. This water would be discharged to either surface water or groundwater. The design would identify the most cost effective long-term discharge approach for the water from the South Open Cut or South Mine. It is unlikely that treatment would be required prior to discharge. If treatment is required, the water would discharge to a passive treatment system. Water would be treated with a passive technology such as Sulfate Reducing Bacteria (SRB) bioreactors or a contact media reactor (Bauxsol, appatite). The actual technology would be determined during design studies. If the water is to be discharged to the unnamed tributaries to Lord Brook it will be treated, if necessary, to meet discharge standards based on Vermont Water Quality Standards. If water is discharged to groundwater it will meet Vermont Groundwater Protection and federal Safe Drinking Water Act standards. Some impacts to wetlands in this area will occur in order to install the access roads, to relocate the waste, dam the pit lake, and fill the cuts. Several small wetlands that are currently receiving acid drainage would be eliminated due to the cleanup efforts. TP-4 would be eliminated as a historic feature. A portion of the South Open Cut would be filled and eliminated as a historic features but the majority of this feature would remain, although the dammed pit lake will partially inundate the area. In addition, all the major features of the South Mine should remain intact since, if possible, the portions of the South Mine not causing acid rock drainage, will be left exposed. Long-term monitoring of the effluent and receiving water would be necessary to evaluate the effectiveness of this alternative. A review of the cleanup action would be performed every five years to ensure that the cleanup is protective of human health and the environment. Institutional controls (land use restrictions) would be put in place to protect the remedy and prevent activities that could cause the exposure and weathering of waste rock. Estimated capital cost: $3.7 million. Estimated annual operation and maintenance costs: $24,600. Present value of capital and maintenance costs: $4.1 million.

Upper and Lower Copperas Factories (CF)

CF 1 – No Action. This alternative is required by statute as a baseline to identify the consequence of taking no action at the Site. This alternative would not include any actions to limit public exposure to the lead contaminated soil within and surrounding the former Upper and Lower Copperas Factories which was determined to be a threat to human health. No monitoring or other actions would be included. There are no capital or long term costs associated with this alternative, except for the cost of conducting a review of the remedy, at a minimum, every five years. The estimated cost for each five year review is $15,000. The present value of the five year reviews is $32,450.

CF 2 - Excavation and on-site treatment of lead contaminated soil with on-site disposal. This alternative would include the excavation of approximately 2,700 cubic yards of soil with lead concentrations above 400 mg/kg. The lead contaminated soil would be treated to solidify and/or stabilize the lead such that the soil no longer exhibits the leaching characteristics of a hazardous waste, thus allowing on-Site burial as a solid waste. The treated soil would be placed in TP-1 and buried beneath a two foot soil cover. There would be impacts to the wetlands area adjacent to the Copperas Factories due to construction access and grading. These areas would be restored as part of the cleanup action. The Copperas Factories are historic features. While the excavation program would be implemented to minimize the impact on the foundations, it is possible that the foundations could collapse as a result of the cleanup action. Mitigation of the historic impacts would include data recovery activities prior to the excavation of the contaminated soil. Estimated capital costs: $1.5 million. Estimated present value of capital costs $1.6 million

CF 4 - In place covering of lead contaminated soil and institutional controls – Preferred Alternative. This alternative would involve the placement of a two foot soil cover over the lead contaminated soil. The NTCRA design would determine whether the Upper Copperas Factory could remain after implementation of the NTCRA. If the Upper Copperas Factory is eliminated by the NTCRA, then the contaminated soil would be consolidated with the Lower Copperas Factory. There would be impacts to the wetlands area adjacent to the Copperas Factories due to construction access and grading. These areas may be restored as part of the cleanup action. The Copperas Factories are historic features. While the grading and covering activities would be implemented to minimize the impact on the foundations, it is possible that the foundation could collapse as a result of the cleanup action. Mitigation of the historic impacts would include data recovery activities prior to the excavation of the contaminated soil. A review of the cleanup action would be performed every five years to ensure that the cleanup is protective of human health and the environment. Monitoring and institutional controls (land use restrictions) would be put in place to protect the remedy. Estimated capital costs: $0.6 million. Estimated annual operation and maintenance costs: $10,830. Estimated present value of capital and maintenance costs $0.8 million.

Site-Wide Sediments (Lower Copperas Brook, WBOR Mixing Zone, Unnamed Tributaries to Lord Brook)

SED 1 – No Action. This alternative is required by statute as a baseline to identify the consequence of taking no action at the Site. This alternative would not include any action to address the sediments that may be acutely toxic to aquatic organisms. This alternative would not include any monitoring or evaluation of the sediments to determine if the sediments remain toxic. There are no costs associated with this alternative, except for the cost of conducting a review of the remedy, at a minimum, every five years. The estimated cost for each five year review is $15,000. The present value of the five year reviews is $32,450.

SED 2 – Monitored natural recovery – Preferred Alternative. This alternative would rely upon natural processes to restore the impacted sediments. Once the source areas are controlled by the implementation of the NTCRA and LBSA cleanup actions, the release of tailing and/or weathered waste rock into Site sediments would cease. This would allow natural scouring and depositional activities to reduce the concentration of contamination in the surficial sediment. Acid mine drainage from upstream would be also be significantly reduced, resulting in less contaminants being chemically leached out of the sediments from the low pH (acidic) run-off. Monitoring of the chemistry and biology of these systems and additional toxicity testing would be necessary to track long-term progress.

No historic resources would be affected by this alternative and no impacts to wetlands or floodplain areas are anticipated. A review of the cleanup action would be performed every five years to ensure that the cleanup is protective of human health and the environment. Estimated capital costs: $0.1 million for the baseline monitoring program. Estimated annual monitoring costs: $9,750. Present value of the monitoring program is $0.4 million.

SED 3 – Excavation of impacted sediment and on-site consolidation. This alternative would involve the excavation of the sediment identified as toxic to aquatic organisms. This includes lower Copperas Brook, the unnamed tributaries to Lord Brook extending from the source areas (South Mine, South Open Cut, and TP-4) to Lord Brook, and the initial 150 feet of the West Branch of the Ompompanoosuc River below the confluence with Copperas Brook. The excavated sediments would be disposed on site. There would be significant short-term impacts to wetland and floodplain resources from this alternative. However, disturbed areas would be restored after the excavation. A review of the cleanup action would be performed every five years to ensure that the cleanup is protective of human health and the environment. Estimated capital cost: $2.8 million. Estimated annual maintenance and monitoring costs: $36,919. Present value of capital costs and maintenance is $3.3 million.

WWII-Era Infrastructure Area (IA)

IA 1 – No Action: This alternative is required by statute as a baseline to identify the consequences of taking no action at the Site. This alternative would not include any actions to abate or monitor the run-off from the exposed waste rock in the WWII-Era Infrastructure Area. There are no costs associated with this alternative, except for the cost of conducting a review of the remedy, at a minimum, every five years. The estimated cost for each five year review is $15,000. The present value of the five year reviews is $32,450.

IA 2 – Diversion of surface water run-on/run-off; limited regrading and cover of surficial mine wastes. This alternative includes actions to eliminate the discharge of acid rock drainage from this area. A combination of surface water run-on/run-off controls, along with the placement of a cover over the graded mine waste, would eliminate the acid rock drainage from this area. Historic resources would be unavoidably affected by this alternative since several of the WWII buildings, which are in a significant state of decay, would be demolished. There are no wetlands or defined floodplain areas in the area to be altered. Long-term monitoring would be included in this alternative. A review of the cleanup action would be performed every five years to ensure that the cleanup is protective of human health and the environment. Institutional controls (land use restriction) would prevent the exposure and subsequent weathering of the mine waste that is currently covered. Estimated capital costs: $1 million. Estimated annual maintenance and monitoring costs: $15,150. Present value of capital and maintenance costs is $1.2 million.

IA 3 – Complete removal of waste ore with consolidation onto TP-1. This alternative would include the removal of all of the exposed and buried waste rock in the WWII Infrastructure area. The estimated 60,000 cubic yards of material would be placed on TP-1. The excavated area would be graded and vegetated to stabilize the area. Historic resources would be unavoidably affected by this alternative. Many of the WWII era buildings would be demolished. Wetlands adjacent to the 1898 adit may be impacted as part of this alternative. These wetlands currently receive acid mine drainage from the adit. Estimated capital costs: $5 million. Estimated annual monitoring and maintenance costs: $10,435. Present value of capital and maintenance costs: $5.1 million.

IA 4 – Limited Action: Monitoring and land use restrictions – Preferred Alternative. This alternative includes monitoring of surface water run-off from the WWII-Era Infrastructure area and land use restrictions to prevent the exposure and subsequent weathering of the waste rock buried in this area. This alternative assumes that after the NTCRA actions are completed Copperas Brook will achieve federal Clean Water Act and Vermont Water Quality Standards for a Class B water without any additional actions to grade and cover the exposed mine waste in this area. No historic resources will be impacted by this alternative. Long-term monitoring of surface water would be necessary to evaluate the effectiveness of the cleanup action. A review of the cleanup action would be performed every five years to ensure that the cleanup is protective of human health and the environment. Institutional controls (land use restriction) would be utilized to prevent the exposure and subsequent weathering of the mine waste that is currently covered, along with compliance monitoring of the institutional controls. Estimated annual monitoring costs: $17,850. Present value of long-term monitoring: $0.230 million.

Site Wide Alternatives (Groundwater and Institutional Controls)

SW 1 - No Action. This alternative is required by statute as a baseline to identify the consequence of taking no action at the Site. This alternative would not include any activities to prevent exposure to contaminated groundwater, to protect the actions implemented as part of the NTCRA, or to perform long-term monitoring of the groundwater. There are no costs associated with this alternative, except for the cost of conducting a review of the remedy, at a minimum, every five years. The estimated cost for each five year review is $15,000. The present value of the five year reviews is $32,450.

SW 2 – Institutional controls and long-term monitoring – Preferred Alternative. This alternative includes Institutional Controls (land use restrictions) to prevent:

- future consumption of the groundwater beneath and adjacent to TP-1, TP-2, and TP-3 that is within the Waste Management Area;
- future consumption of groundwater within the underground mine workings; and
- any disturbance of the land occupied by the NTCRAand TCRA response actions that would reduce the effectiveness or increase the monitoring and maintenance of the NTCRA and TCRA response actions.

EPA has made a finding that it would be technically impracticable from an engineering perspective to achieve the cleanup of the groundwater in the Underground Workings. Therefore, CERCLA permits EPA to waive the regulatory requirements to cleanup the groundwater within the Technical Impracticability Zone (the Underground Workings). This alternative would also include institutional controls, long-term monitoring, and five-year reviews to ensure that public health is protected. There are no historic resources that would be affected by this alternative, since the Underground Workings would be left intact. Some unavoidable impacts to wetland and/or floodplain areas may occur as a result of the installation of monitoring wells or as part of the long-term monitoring program.

The State's long-term monitoring and maintenance of the NTCRA and TCRA response actions will be incorporated into the remedial action since monitoring and maintenance of the covers on the tailing piles maintains the protectiveness of the groundwater remedy. This Alternative also includes groundwater monitoring to assess alternative CF 4 as part of the overall groundwater monitoring and assessment program. The soil cover installed as part of CF 4 will be within the Waste Management Area.

Estimated capital costs for establishing the institutional controls, monitoring wells and baseline monitoring: $0.4 million. Estimated annual monitoring costs: $12,450. Prevent value of capital and long-term monitoring costs: $0.54 million. This estimate does not include long-term NTCRA and TCRA maintenance costs to be incorporated into the remedy, that are described within the NTCRA and TCRA decision documents.

K. SUMMARY OF THE COMPARATIVE ANALYSIS OF ALTERNATIVES

Section 121(b)(1) of CERCLA presents several factors that at a minimum EPA is required to consider in its assessment of alternatives. Building upon these specific statutory mandates, the NCP articulates nine evaluation criteria to be used in assessing the individual remedial alternatives.

A detailed analysis was performed on the alternatives using the nine evaluation criteria in order to select a site remedy. The following is a summary of the comparison of each alternative's strengths and weaknesses with respect to the nine evaluation criteria. These criteria are summarized as follows:

Threshold Criteria

The two threshold criteria described below must be met in order for the alternatives to be eligible for selection in accordance with the NCP:

1. Overall protection of human health and the environment addresses whether or not a remedy provides adequate protection and describes how risks posed through each pathway are eliminated, reduced or controlled through treatment, engineering controls, or institutional controls.

2. Compliance with applicable or relevant and appropriate requirements (ARARs) addresses whether or not a remedy will meet all Federal environmental and more stringent State environmental and facility siting standards, requirements, criteria or limitations, unless a waiver is invoked.

Primary Balancing Criteria

The following five criteria are utilized to compare and evaluate the elements of one alternative to another that meet the threshold criteria:

3. Long-term effectiveness and permanence addresses the criteria that are utilized to assess alternatives for the long-term effectiveness and permanence they afford, along with the degree of certainty that they will prove successful.

4. Reduction of toxicity, mobility, or volume through treatment addresses the degree to which alternatives employ recycling or treatment that reduces toxicity, mobility,

or volume, including how treatment is used to address the principal threats posed by the Site.

5. Short-term effectiveness addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period, until cleanup goals are achieved.

6. Implementability addresses the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.

7. Cost includes estimated capital and Operation and Maintenance costs, as well as present-worth costs.

Modifying Criteria

The modifying criteria are used as the final evaluation of remedial alternatives, generally after EPA has received public comment on the RI/FS and Proposed Plan:

8. State acceptance addresses the State's position and key concerns related to the preferred alternative and other alternatives, and the State's comments on ARARs or the proposed use of waivers.

9. Community acceptance addresses the public's general response to the alternatives described in the Proposed Plan and RI/FS.

Following the detailed analysis of each individual alternative, a comparative analysis, focusing on the relative performance of each alternative against the nine criteria, was conducted. This comparative analysis can be found in Sections 4.4, 5.3, 6.3, 7.3, and 8.5 of the FS.

The section below presents the nine criteria and a brief narrative summary of the alternatives and the strengths and weaknesses according to the detailed and comparative analysis. Only those alternatives that satisfied the first two threshold criteria were balanced and modified using the remaining seven criteria.

Comparative Analysis of Alternatives

Each alternative is evaluated using the two threshold and five balancing criteria in detail as part of the FS. After completion of the detailed evaluation of alternatives, a comparative analysis of the alternatives was performed to identify the alternative that satisfies the two threshold criteria of protection of human health and the environment and compliance with ARARs. Then the alternatives are assessed to determine which is the best option based on the five balancing criteria. The comparative analysis from the FS is summarized below.

Threshold Criteria

1. Overall Protection of Human Health and the Environment.

Lord Brook Source Area Alternatives: LSBA 1, the No Action alternative, would not be protective of human health and the environment since no action would be taken to abate the acid rock drainage that is causing unacceptable ecological impacts to the unnamed tributaries to Lord Brook and to Lord Brook. The other three alternatives (LBSA 2B, LBSA 3, and LBSA 4) would all be protective of human health and the environment by preventing the release of acid rock drainage into the unnamed tributaries to Lord Brook and to Lord Brook. LBSA 3 and LBSA 4 achieve a higher degree of protection of the environment since they include actions to eliminate or control the source of the acid rock drainage.

Copperas Factory Alternatives: CF 1, the No Action Alternative, would not be protective of human health and the environment since no action would be taken to prevent human exposure to the lead contaminated soil that was identified as an unacceptable threat to humans. The other two alternatives, CF-2 and CF-4, would be protective of human health and the environment by preventing human exposure to lead contaminated soil.

Sediment Alternatives: SED 1, the No Action Alternative, would not be protective of human health and the environment since no action would be taken to address the contaminated sediments that were identified as an unacceptable ecological threat to aquatic organisms. SED 2 would be protective of human health and the environment because natural recovery processes, after the completion of the NTCRA and LBSA alternative, will eliminate the source of contaminated sediments thus allowing the natural processes to decrease the sediment toxicity over time. Monitoring would assess the continued protectiveness of the remedy. SED 3 would be protective of human health and the environment by removing the contaminated sediments and restoring the impacted areas.

WW II-Era Infrastructure Alternatives: IA 1, the No Action Alternative, would not be protective of human health and the environment since no action would be taken to prevent the release of acid rock drainage from the WWII-Era Infrastructure Area or to monitor whether the NTCRA has fully addressed the threat from this area. IA 4, the limited action alternative, would be protective of human health and the environment since it includes monitoring to determine whether Copperas Brook achieves water quality standards at the end of the NTCRA and institutional controls to prevent the exposure of mine waste that cause additional acid rock drainage from this area. IA 2 and IA 3 would be protective of human health and the environment by eliminating the discharge of acid rock drainage from this area to Copperas Brook.

Site Wide Alternatives: SW 1, the No Action Alternative, would not be protective of human health and the environment since it includes neither any measures to prevent human consumption of contaminated groundwater nor any monitoring of contaminated groundwater. SW 2 would be protective of human health and the environment since it would include land use restrictions to prevent consumption of contaminated groundwater beneath and adjacent to TP-1, TP-2, and TP-3 and within the underground mine workings. The land use restrictions in SW 2 would also ensure the long-term effectiveness of the NTCRA and TCRA response actions and would include long-term monitoring of groundwater.

2. Compliance with ARARs.

Lord Brook Source Area Alternatives: LSBA 1, the No Action alternative, would not comply with the ARARs, since contaminant risks would not be addressed. The LBSA 1 ARARs are listed in Table 4-4 of the FS. Specifically, LBSA 1 would allow the surface water of the unnamed tributaries to Lord Brook and to Lord Brook to continue to violate the federal Clean Water Act and the Vermont Water Quality Standards. The other three alternatives (LBSA 2, LBSA 3, and LBSA 4) would all comply with the ARARs. The ARARs for the preferred alternative, LBSA 4, are identified in Table 92 of the ROD. The ARARs for LBSA 2 are listed in Table 4-5 of the FS. The ARARs for LBSA 3 are listed in Table 4-6 of the FS. To the extent federal jurisdictional wetlands and aquatic resources would be altered by the alternative, EPA has identified LBSA 4 as the least damaging practicable alternative based on the analysis required in 40 C.F.R. Part 230 of the federal Clean Water Act regulations. EPA has also identified unavoidable impacts to historic properties that would be necessary to abate the threat to human health and the environment. LBSA 2 would have the least historic impacts, LBSA 3 would permanently alter some historic resources, while LBSA 4 would likely eliminate all historic resources. Mitigation would be carried out, to the extent required by the applicable ARARs, to address impacts to historic resources. LBSA 2, LBSA 3, and LBSA 4 would achieve federal and State water quality standards at compliance points located downstream of the area, at the point of perennial flow of the unnamed streatms that drain the area.

Copperas Factory Alternatives: CF 1, the No Action Alternative, would not comply with ARARs, since contaminant risks would not be addressed. The ARARs for CF 1 are listed in Table 5-1 of the FS. The other two alternatives, CF-2 and CF-4, would comply with the ARARs identified in Table 5-2 of the FS and Table 92 of the ROD, respectively. However, EPA has identified unavoidable impacts to wetlands and historic properties that would be necessary under both of these alternatives to abate the threat to human health and the environment. Mitigation would be carried out, to the extent required by the applicable ARARs, to address impacts to wetlands and historic resources.

Sediment Alternatives: SED 1, the No Action Alternative, would not comply with ARARs since contaminant risks would not be addressed. The ARARs for SED 1 are listed in Table 6-1 of the FS. The other two alternatives, SED 2 and SED 3, would comply with the ARARs identified in Table 94 of the ROD and Table 6-3 of the FS, respectively. No impacts to historic resources would be anticipated from these alternatives. EPA has identified unavoidable impacts to wetlands that would be necessary for alternative SED 3 to abate the threat to human health and the environment. EPA has identified SED 2 as the least damaging practicable alternative based on the analysis required in 40 C.F.R. Part 230 of the federal Clean Water Act regulations since the environmental cleanup standards can be achieved without physically altering existing wetland and aquatic resources.

WW II-Era Infrastructure Alternatives: IA 1, the No Action Alternative, would not comply with ARARs , since contaminant risks would not be addressed. The ARARs for IA 1 are listed in Table 7-1 of the FS. The other three alternatives, IA 2, IA 3, and IA 4 would comply with the

ARARs identified in Tables 7-2 of the FS, 7-3 of the FS, and Table 95 of the ROD, respectively. IA 3 may potentially alter wetland resources. EPA has also identified unavoidable impacts to historic properties that would be necessary for alternatives IA 2 and IA 3 to abate the threat to human health and the environment. Mitigation would be carried out, to the extent required by the applicable ARARs, to address impacts to wetlands and historic resources. Alternative IA 4 would not impact any wetland or historic resources. IA 2, IA 3, and IA 4 would achieve federal and State water quality standards at a compliance point on Copperas Brook located downstream of TP-1, once the NTCRA action remediates TP-1 and TP-2.

Site Wide Alternatives: SW 1, the No Action Alternative, would not comply with ARARs, since contaminant risks would not be addressed. The ARARs for SW 1 are listed in Table 8-1 of the FS. SW 2 would comply with the ARARs identified in Table 96, except for the requirements of the Vermont Groundwater Protection Rule and Strategy and federal Safe Drinking Water Act to achieve standards for the water within the Underground Workings (mine pool). EPA has determined that it is technically impracticable, from an engineering perspective, to achieve the Primary Groundwater Enforcement Standards from the Vermont Groundwater Protection Rule and Strategy or federal Safe Drinking Water Act maximum contaminant levels (MCLs) or non-zero maximum contaminant level goals (MCLGs) for the groundwater within the Underground Workings. Therefore, EPA is waiving this ARAR, as permitted under CERCLA for the groundwater within the Underground Workings. This is due primarily to the fact that there is no practicable option that would prevent water from entering the underground working or which would eliminate the source of sulfur or metals in the bedrock surfaces and remaining waste rock within the Underground Workings. These groundwater standards remain ARARs for the rest of the Site, except for the areas under the waste management areas (tailing piles) to be remediated under the NTCRA.

Balancing Criteria

3. Long-term Effectiveness and Permanence.

Lord Brook Source Area Alternatives: LBSA 3 would offer the highest degree of long-term effectiveness and permanence by eliminating the release of acid rock drainage and by covering the acid generating waste material. LBSA 4 would offer a similar level of protection by eliminating the most significant sources of acid rock drainage. Alternative LBSA 4 does, however, rely on institutional controls and maintenance of the pit lake and associated dam at the South Open Cut and the assimilation of the low residual flow from the areas of the South Open Cut and South Mine into the groundwater or surface water to achieve full protectiveness. Alternative LBSA 2B would also satisfy this criteria. However, LBSA 2B is dependent upon innovative treatment technologies with no long term record of performance. Both LBSA 4 and 2B are more dependent than LBSA 3 upon institutional controls and long-term operation and maintenance in order to maintain the effectiveness. LBSA 4 would provide a greater degree of effectiveness and permanence than LBSA 2B since it would utilize the substantial capacity of the South Open Cut as a detention basin to prevent an overflow of the system during high flow events. The capacity of the South Open Cut also allows for storage of water when cold weather could cause the discharge pipe to freeze. LBSA 1 would not satisfy this criterion.

Copperas Factory Alternatives: CF 2 and CF 4, would both offer long-term effectiveness and permanence. CF 4 would offer a somewhat higher degree of long-term effectiveness and permanence by excavating the lead contaminated soil from its current location and permanently stabilizing the lead contaminated soil to make it inert. CF 4 would rely upon long-term maintenance and institutional controls to maintain the cover system over the lead contamination. CF 1 would not satisfy this criterion.

Sediment Alternatives: SED 2 and SED 3 would both offer long-term effectiveness and permanence. SED 3 would offer a somewhat higher degree of long-term effectiveness by removing the contaminated sediments and placing them in a location that would not allow for re-entry into the aquatic environment. SED 2 would achieve long-term effectiveness and permanence once NTCRA and LBSA components of the remedy eliminate the sources of contaminated sediments and ARD. Once those measures are achieved, sediment burial and transport processes will cause the sediments to no longer be acutely toxic and the reduction in the acidity of the waterways would make contaminants less mobile. There is some possibility that re-exposure of buried sediments could occur in the future. However, the potential for the exposure of an area of contaminated sediments causing a significant impact on the aquatic system is low. SED 1 would not satisfy this criterion.

WW II-Era Infrastructure Alternatives: IA 3 would offer the highest degree of long-term effectiveness and permanence by removing the mine waste and placing that waste under a cover system on TP-1. IA 2 would offer a similar degree of long-term effectiveness and permanence by controlling surface water run-on and run-off and covering mine waste to eliminate the acid rock drainage. Institutional controls in the form of land use restrictions would also be required to prevent future site disturbance. IA 4 would satisfy this criterion by including a monitoring program to ensure that the post-NTCRA run-off from the WWII-Era Infrastructure Area does not cause any exceedance of water quality standards at the compliance point in Copperas Brook and through the implementation and monitoring of land use restrictions to prevent the exposure of additional mine waste. IA 1 would not satisfy this criterion.

Site Wide Alternatives: SW 2 would satisfy this criterion through land-use restrictions, with compliance monitoring, that would prevent future consumption of the groundwater within the Waste Management Area for TP-1, TP-2, and TP-3, as well as the water within the Underground Workings. Long-term maintenance of the NTCRA and TCRA response actions would also meet this criterion. Monitoring of groundwater to assess the long-term permanence and effectiveness of the remedy would also be required. SW 1 would not satisfy this criterion.

4. Reduction of Toxicity, Mobility, or Volume through Treatment.

Lord Brook Source Area Alternatives: LBSA 2B would include treatment of the surface water discharge from the South Open Cut and South Mine that reduces the toxicity, mobility, or volume of contamination. LBSA 4 would reduce acid generation by increasing the water level in the South Open Cut it lake and may include adding a source of alkalinity in the back fill in the South Open Cut and the bottom of the South Mine pit lake to accomplish treatment of acid generating material. LBSA 1 and LBSA 3 do not include treatment.

Copperas Factory Alternatives: CF 2 would include treatment of the lead contaminated soil to stabilize the lead and render it a non-hazardous waste. CF 4 and CF 1 do not include treatment.

Sediment Alternatives: SED 1, SED 2, and SED 3 do not include treatment.

WW II-Era Infrastructure Alternatives: IA 1, IA 2, IA 3, and IA 4 do not include treatment.

Site Wide Alternatives: SW 1 and SW 2 do not include treatment.

5. Short-term Effectiveness.

Lord Brook Source Area Alternatives: LBSA 3 and LBSA 4 would achieve the cleanup objectives in the shortest time frame. Once the mine waste is deposited in the cut and covered, the acid rock drainage from those areas should cease. Once the treatment system for LBSA 2B was operational, the impacts from the acid rock drainage should cease. However, the treatment systems would require operation in perpetuity for the effectiveness to be maintained. Short term impacts associated with the construction activities of LBSA 2B, LBSA 3, and LBSA 4 would all be addressed through the design and implementation of best management practices. However, LBSA 3 would have significant short-term impacts associated with the excavation of the areas of waste rock at the South Mine and South Open Cut. These areas are currently stable and are not considered to be major contributors to the acid rock drainage at the Site. Additional short term impacts from LBSA 3 could occur if sufficient fill material is not available on-site and substantial quantities of material must be obtained from off-site locations. LBSA 1 would not achieve this criterion.

Copperas Factory Alternatives: CF 2 and CF 4 would achieve protection in a similar time frame. Short term impacts associated with the construction activities of CF 2 and CF 4 would all be addressed through the design and implementation of best management practices. CF 1 would not achieve this criterion.

Sediment Alternatives: SED 3 would achieve the restoration in the shortest time period. Once the sediments are excavated, the impacts would cease and recovery would occur. Short term impacts associated with the construction activities of SED 3 would all be addressed through the design and implementation of best management practices. SED 2 relies on the completion of the NTCRA and LBSA source control measures and upon longer term natural processes that could require more than ten years to achieve the complete reduction in sediment contamination levels to eliminate acute toxicity. SED 1 would not achieve this criterion.

WW II-Era Infrastructure Alternatives: IA 2 and IA 3 would achieve the objective of eliminating acid rock drainage in the shortest time period. IA 4 would achieve its objectives once the NTCRA source control measures are completed and post-NTCRA monitoring demonstrates that Copperas Brook achieves water quality standards. Short term impacts associated with the construction activities of IA 2 and IA 3 would all be addressed through the design and implementation of best management practices. IA 1 would not achieve this criterion.

Site Wide Alternatives: The time period to achieve effectiveness for SW 2 would depend upon the time required to implement the land use restrictions. The long-term maintenance of the NTCRA and TCRA response actions as part of the Remedial Action would begin upon completion of these response actions and initiation of the Remedial Action. No short term impacts are associated with this alternative and no individuals are currently consuming mine impacted groundwater.

6. Implementability

Lord Brook Source Area Alternatives: LBSA 2B would use an innovative technology. This technology is believed to be capable of achieving the performance objectives for the Site, but a full scale demonstration would be necessary to ensure that the technology can achieve the performance objectives. LBSA 3 and LBSA 4 would utilize standard construction practices. Some specialty work would be included to stabilize the rock walls of the South Open Cut. The materials and services necessary to implement all of these alternatives are readily available, although LBSA 3 may be more difficult to implement if sufficient material to completely fill the South Open Cut has to be transported from off-site. LBSA 1 would be easily implemented, since it only requires conducting 5-year reviews of the remedy.

Copperas Factory Alternatives: CF 2 and CF 4 are considered to be implementable. The materials and services necessary to implement these alternatives are readily available. CF 1 would be easily implemented, since it only requires conducting 5-year reviews of the remedy.

Sediment Alternatives: SED 2 and SED 4 are considered to be implementable, but SED 4 would involve alteration of wetlands and waterways (that would then require restoration) and transportation and on-site disposal of contaminated sediments. The materials and services necessary to implement these alternatives are readily available. SED 1 would be easily implemented, since it only requires conducting 5-year reviews of the remedy.

WW II-Era Infrastructure Alternatives: IA 2, IA 3, and IA 4 are considered to be implementable, although IA 2 and IA 3 would involve the demolition of historic buildings. The materials and services necessary to implement these alternatives are readily available. IA 1 would be easily implemented, since it only requires conducting 5-year reviews of the remedy.

Site Wide Alternatives: SW 2 is considered to be implementable. The materials and services necessary to implement these alternatives are readily available. SW 1 would be easily implemented, since it only requires conducting 5-year reviews of the remedy.

7. Cost.

Lord Brook Source Area Alternatives: LSBA 1 is the lowest cost, but does not meet the threshold criteria. LBSA 2B and LBSA 4 have similar costs and would be the lowest cost alternatives that meet the threshold criteria. LBSA 3 has higher short term capital costs and a higher present value than the other alternatives.

Copperas Factory Alternatives: CF 1 is the lowest cost, but does not meet the threshold criteria. CF 4 is the least expensive of the alternatives that meet the threshold criteria. CF 2 is more expensive.

Sediment Alternatives: SED 1 is the lowest cost, but does not meet the threshold criteria. SED 2 is the least expensive of the alternatives that meet the threshold criteria. SED 3 is more expensive.

WW II-Era Infrastructure Alternatives: IA 1 is the lowest cost, but does not meet the threshold criteria. IA 4 is the least expensive of the alternatives that meet the threshold criteria. IA 3 is the next lowest cost and IA 2 has the highest cost.

Site Wide Alternatives: SW 2 is the least expensive of the alternatives that meet the threshold criteria.

Modifying Criteria

8. State Acceptance.

The evaluation of this criterion is based on the input from the State throughout the evaluation process to develop a remedy for the Site. EPA has a clear understanding of the State perspective with respect to the cleanup options under consideration and has addressed the State's questions and comments raised during the public comment period within the Responsiveness Summary (Appendix C). Over the past six years, EPA has committed substantial resources to involve the State in the cleanup process. The alternatives presented in the FS, Proposed Plan, and this ROD reflect the dialogue between EPA, VTDEC and other State officials.

The VTDEC has actively participated in the planning, implementation, and assessment of the RI/FS. -VTDEC has partnered with EPA in the implementation of the cleanup action at the Site. As a fund lead action, VTDEC is responsible for 10% of the capital cost and 100% of the operation and maintenance cost of the cleanup action (including long-term O & M of the NTCRA and TCRA response actions). VTDEC has notified EPA that it concurs with the cleanup approach presented in this ROD (Appendix B).

9. Community Acceptance

The evaluation of this criterion is based on the input from the community throughout the evaluation process to develop a remedy for the Site. EPA has a clear understanding of the community perspective with respect to the cleanup options under consideration and has addressed the community's questions and comments raised during the public comment period within the Responsiveness Summary (Part 3). Over the past six years, EPA has committed substantial resources to involve the community in the cleanup process. The alternatives presented in the FS, Proposed Plan, and this ROD reflect the dialogue between EPA and the community.

In particular, the Elizabeth Mine Community Advisory Group (EMCAG) had a major influence on the developing the remedy described in this ROD. The regular EMCAG meetings over the past six years have provided an opportunity for EPA to gain insight into the community's perspective on many issues. This input was considered during the development of the FS. Truck traffic, road damage, public health concerns, overall cost and the financial burden to the State of

Vermont, impacts to historic resources, restoration of the environmental impacts, and a desire to achieve the cleanup in a permanent manner in the shortest possible time-frame are among the major issues consistently identified by the EMCAG as community concerns. EPA has presented the findings of the RI at EMCAG meetings since 2004 and began introducing the major FS components and issues in late 2005. Discussion between EPA and the community regarding the FS alternatives have been ongoing since January 2006 when EPA presented a summary of the FS alternatives at the January 2006 EMCAG. The TAG and TOSC consultants to the community also had an opportunity to review and comment on the RI/FS documents in advance of the comment period. The EMCAG met on June 14, 2006 to discuss the alternatives presented in the Feasibility Study and Proposed Plan.

L. THE SELECTED REMEDY

1. Summary of the Rationale for the Selected Remedy

The selected remedy for the Elizabeth Mine is a comprehensive remedy for the Site. The selected remedy targets the principal threat waste, which is the lead contaminated soil at the Upper and Lower Copperas Factories. The lead contaminated soil will be contained in place to allow for the preservation of the historic resources. The remaining waste at the Site is characterized as large volume low level threat waste that is causing ecological impacts to surface water and sediments. The selected remedy is the proposed preferred alternative for each area as identified in the Proposed Plan and presented in more detail in the FS.

2. Description of Remedial Components

Lord Brook Source Areas, Alternative LBSA 4 – Partial consolidation of surficial mine waste and surface water diversion with discharge of water to tributary of Lord Brook or groundwater. This alternative minimizes the discharge of acid rock drainage from the three Lord Brook Source Areas (South Open Cut, South Mine, and TP-4). To accomplish this, exposed waste rock from TP-4 and a portion of the waste rock from the South Mine will be consolidated into the dry portion of the South Open Cut and placed under a cover that will promote surface run-off. The majority of the buried waste rock surrounding the South Open Cut or South Mine will remain in place to minimize disturbance to the forest and the historic features. The amount of material removed from the South Mine area will be determined during design. It is possible that the pit lake within the South Mine may be drained to allow for the removal of waste rock that may be located within the pit lake. The South Mine pit lake would be allowed to re-establish itself and would serve as a detention basin as part of the surface water control system within the area. The South Open Cut pit lake would also remain and would have an increased water level due to the installation of a dam at the outlet. The dam would retain water in the pit lake to control outflows and to inundate areas of acid generating rock within the Cut. The design would determine the optimal location for a dam to prevent the uncontrolled release of water from the South Open Cut pit lake. EPA has determined that LSBA-4 is the least damaging practicable alternative to achieve the protection of downstream wetlands and aquatic resources from acid rock drainage. To the extent federally regulated wetlands are identified outside the limits of the waste management area, the altered resources will be restored. EPA has also determined that there will be unavoidable impacts to historic resources. LBSA 4 will achieve federal and State water quality standards at the downstream compliance points on the unnamed tributaries of Lord Brook that drain the area. Alternative LBSA 4 is shown in Figure 22.

The primary elements of alternative LBSA 4 are:

- Construction of clean surface water diversions around the South Mine and the South Open Cut/TP-4.

- Excavation of waste ore from the South Mine, with consolidation into the South Open Cut. The amount of material to be re-located will be determined during the design. The objective will be to minimize the extent of disturbance to areas that are not contributing to the acid rock drainage release and to also minimize the impact to historic features. The pit lake would be allowed to restore itself and serve as a detention basin.

- Excavation of TP-4 waste rock and waste ore with consolidation into the dry portion of the South Open Cut.

- Installation of a dam in the vicinity of the haul road from the South Open Cut to contain the pit lake, inundate areas of acid generating rock in the Cut, and allow for a controlled release of water from the pit lake.

- Discharge of water from the South Open Cut and South Mine pit lakes via either direct discharge to surface water into the tributary to Lord Brook or infiltration into the ground. Discharge of the water from the South Open Cut to the Underground Workings will also be evaluated. An estimated flow of 2 gallons per minute for the South Open Cut and 5 gallons per minute from the South Mine are estimated as the long-term discharge rates.

- Covering of areas of consolidated mine wastes in the cuts with a vegetative soil cover to act as a contact barrier and to promote vegetative growth and possible addition of lime or other buffering agents.

- Covering areas from which waste rock has been excavated (e.g., TP-4) to promote vegetative growth and possible addition of lime or other buffering agents.

- Performing maintenance and inspections of the covers.

- Performing monitoring of the unnamed tributaries of Lord Brook and Lord Brook to determine if the actions have restored these waters to federal Clean Water Act and Vermont Class B Water Quality Standards. Monitoring of groundwater if discharges are infiltrated into the ground.

- Institutional controls, such as restrictive covenants, to protect the cleanup action from damage and to ensure that buried waste rock is not exposed in the future. Periodic inspections or other procedures and requirements would be performed to ensure compliance with the institutional controls and to ensure notification to EPA and the State and the appropriate local governments agencies if the institutional control is breached.

- A review of the remedy every 5 years to determine whether the cleanup action remains protective of human health and the environment.

Estimated capital cost of LBSA 4: $3.7 million. Present value of LBSA 4, including capital costs: $4.1 million. Estimated annual operation and maintenance costs: $24,600.

Upper and Lower Copperas Factories, Alternative CF 4 – In-place capping of lead-containing surficial soil and institutional controls. This alternative involves the placement of a two-foot layer of soil over lead contaminated soil within and surrounding the Upper and Lower Copperas Factories to eliminate the human contact risk. Some consolidation of lead contaminated soil may be necessary. In particular, the design will consider whether the Upper Copperas Factory should be consolidated into the Lower Copperas Factories and if the NTCRA TP-3 cleanup action would require removal of the Upper Copperas Factory. Both the Upper and Lower Copperas Factories are considered to be within one Area of Contamination and consolidation of material would not trigger federal or state land disposal restrictions or other placement requirements. The design and construction activities will attempt to preserve the exposed foundations of the Copperas Factories as visible features. EPA has determined that CF 4 is the least damaging practicable alternative with respect to the potential unavoidable impacts to federally regulated wetlands. To extent federally regulated wetlands are identified outside the limits of the waste management area, the altered resources will be restored. The design and construction activities will include measures to minimize the impacts on wetlands through the use of best management practices. EPA has also determined that there will be unavoidable impacts to historic resources. Mitigation measures, if required under applicable historic preservation standards, will be undertaken. Alternative CF-4 is shown in Figure 23.

The primary elements of alternative CF 4 are:

- Placement of a sufficiently thick soil cover over contaminated soil with a lead concentration equal to or exceeding 400 mg/kg to prevent direct human contact risk.

- Preserve Copperas Factory foundations to the extent possible or documentation of historic resources that must by disturbed.

- Preservation of historic artifacts, to the extent practicable.

- Performing monitoring (groundwater monitoring to be addressed under SW-2), maintenance, and inspections of the covers.

- Institutional controls, such as restrictive covenants, to protect the cleanup action from damage. Periodic inspections or other procedures and requirements would be performed to ensure compliance with the institutional controls and to ensure notification to EPA and the State and the appropriate local governments agencies if the institutional control is breached.

- A review of the remedy every 5 years to determine whether the cleanup action remains protective of human health and the environment.

Estimated capital cost of CF 4: $0.6 million. Present value of CF 4, including capital costs: $0.7 million. Estimated annual monitoring costs: $10,830.

Impacted Sediment, Alternative SED 2 – Monitored natural recovery. This alternative relies upon natural processes, such as long-term burial and dispersion to change the distribution of contaminated sediments. The long-term result will be that the sediments are no longer toxic to aquatic organisms and the sediments do not cause the surface water to fail Vermont Class B Water Quality Standards. The NTCRA and LBSA cleanup actions will eliminate the contaminant loading and acidification of Copperas Brook, WBOR, and the unnamed tributaries of Lord Brook. There would be no construction activities associated with this alternative. EPA would perform an initial baseline surface water and biological monitoring program. Long-term monitoring of surface water, sediment, and the biological community would be performed. It is possible that some impacts to wetland areas could occur in order to perform the monitoring program. These impacts would be minimized by best management practices and impacted areas would be restored. EPA has determined that SED 2 is the least damaging practicable alternative with respect to the potential unavoidable impacts to federally regulated wetlands. The cleanup action would be reviewed every five years. Alternative SED 2 is shown in Figures 24 and 25.

The estimated cost of the baseline monitoring program is $0.1 million. The present value of all monitoring, including the baseline monitoring is $0.4 million. Estimated annual monitoring costs: $9,750.

WW II- Era Infrastructure Area, Alternative IA 4 – Limited action (institutional controls and monitoring). This alternative relies upon the successful implementation of the NTCRA to achieve Vermont Water Quality Standards at the point of compliance in Copperas Brook downstream of TP 1. As a result, the only necessary activities to prevent an increase in acid rock drainage will be monitoring of the water quality at the compliance point along with implementation and monitoring of land use restriction that restricts any alteration of the WWII-Era Mine Infrastructure Area in a manner that would expose waste rock and create additional acid rock drainage. The only costs associated with this alternative would be the actions to implement the land use restrictions, monitoring, and to review this cleanup action every five years. Periodic inspections or other procedures and requirements would be performed to ensure compliance with the institutional controls and to ensure notification to EPA and the State and the appropriate local governments agencies if the institutional control is breached. Alternative IA 4 is shown on Figure 26.

There are no capital costs associated with this alternative. The present value of the monitoring is estimated $253,841. Estimated annual monitoring costs: $17,850.

Site Wide Groundwater, Alternative SW 2 – Site wide groundwater and institutional controls. This alternative includes land use restrictions to prevent future consumption of contaminated groundwater in limited areas of the Site. The contaminated groundwater is found within the Underground Workings of the Elizabeth Mine and within and adjacent to TP-1, TP-2, and TP-3. Some combination of local ordinances, deed notices, and/or restrictive covenants, coupled with periodic monitoring of compliance with the restrictions, would be used to provide awareness that the Underground Workings contain water that is unsuitable for ingestion and to prevent installation of a water supply well into the Underground Workings. No residential wells are currently installed in the Underground Workings. EPA is invoking a statutory Technical Impracticability Waiver, as permitted by CERCLA, for the groundwater within the Underground Workings. EPA has determined that it is technically impracticable, from an engineering perspective, to achieve federal Safe Drinking Act Maximum Contaminant Levels (MCLs), Maximum Contaminant Level Goals (MCLGs) and the State of Vermont Primary Groundwater Quality Standards for the water within the Underground Workings (mine pool). Therefore, EPA is waiving these standards as applicable or relevant and appropriate requirements for the groundwater within the Underground Workings. This waiver applies to all of the inorganic constituents that are present in the naturally occurring material at the Site and specifically to cadmium, copper, manganese, mercury, and nickel which have been detected in the groundwater of the Underground Workings at concentrations above either MCLs, MCLGs, or the Vermont Primary Groundwater Quality Standards.

In addition, restrictive covenants would also be used to prevent future use of the groundwater beneath and adjacent to TP-1, TP-2, and TP-3. One residential well is located within the Waste Management Area for TP-1, TP-2, and TP-3, however, the property is no longer occupied and the well is not currently in use. The groundwater contamination associated with TP-1, TP-2, and TP-3 is within the Waste Management Area. A cross sectional view of the Underground Workings is shown in Figure 13. A plan view of the Waste Management Area, the groundwater compliance areas, the Technical Impracticability Zone is shown on Figure 27.

The restrictive covenants would also include land use restrictions to protect the integrity and long-term effectiveness of the response actions implemented as part of the TCRA and NTCRA. Periodic inspections or other procedures and requirements would be performed to ensure compliance with the institutional controls and to ensure notification to EPA and the State and the appropriate local governments agencies if the institutional control is breached. The long-term monitoring and maintenance activities for the TCRA and NTCRA will be implemented by the State of Vermont as part of this alternative. This alternative includes the installation of additional monitoring wells to provide long-term compliance points. Groundwater monitoring around TP-3 will also include the area where the soil cover is placed over the lead contamination as part of CF 4. The number and location of the wells will be determined during the design. Long-term monitoring of the groundwater and discharge of the Underground Workings at the Artesian Vent will also be included in this alternative. It is possible that some impacts to wetlands and floodplain areas could occur to allow for the installation of the monitoring wells. These impacts would be minimized by best management practices and impacted areas would be restored.

The estimate cost for the establishment of institutional controls, well installation, and initial monitoring is estimated to be $0.4 million. The present value of this alternative, including the monitoring well installation and initial monitoring, is $0.6 million. Estimated annual monitoring costs: $12,450. This estimate does not include long-term NTCRA and TCRA maintenance costs to be incorporated into the remedy, that are described within the NTCRA decision documents.

Points of Compliance

Figure 27 shows the extent of the Waste Management Area and the Technical Impracticability Zone. Groundwater is not required to achieve cleanup levels within these areas. The point of compliance for groundwater will be the outside edge of the Waste Management Area and Technical Impracticability Zone. The surface water points of compliance will generally be the location at which a point source discharges to surface water. The possible locations of the surface water points of compliance are also shown on Figure 27.

Summary of cost

The total costs for the five proposed cleanup actions are presented in Table 84 below. If the cleanup continues as an EPA lead activity, then EPA would implement these cleanup actions. EPA would pay 100% of the costs for the design and 90% of the capital costs to implement the cleanup actions. The State of Vermont would be responsible for 10% of the capital costs and for the full cost and implementation of the long-term operation, maintenance, and monitoring activities. Detailed cost estimates for capital and long-term costs are presented in Tables 85 – 89 which are attached to the ROD.

Table 84

Alternative	Capital or initial monitoring costs (millions)	Estimated annual operation, maintenance, and monitoring costs	Present Value over 30 years
LBSA-4	\$3.75	\$0.025	\$4.1
CF-4	\$0.61	\$0.011	\$0.77
SED-2	\$0.01	\$0.010	\$0.39
IA-4	\$0	\$0.018	\$0.25
SW-2	\$0.34	\$0.010	\$0.54
Total	\$4.71	\$0.074	\$6.05

The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. A 7% discount rate was used to estimate present worth. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. Major changes may be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Difference (ESD), or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to -30 percent of the actual project cost.

3. Expected Outcomes of the Selected Remedy

The primary expected outcome of the selected remedy is that the waste material at the Site will no longer release acid rock drainage or acid mine drainage thereby allowing the aquatic systems to recover. The West Branch of the Ompompanoosuc River and Lord Brook should recover quickly once the source areas are controlled. Copperas Brook and the tributaries to Lord Brook may require additional time to recover due to the retention of contaminants within the sediments. Upon recovery, these aquatic systems are expected to achieve the criteria for a Vermont Class B water and to support a functional biological community. The remedy is also expected to prevent exposure to lead contaminated soil in the Upper and Lower Copperas Factories area and to limited areas of contaminated groundwater under the Waste Management Area and within the Underground Workings. The waste areas would be available for limited re-use. Any future use would need to protect the remedial components, including covers, surface water control structures, and monitoring wells. Since the Site is currently private property, the exact nature of future use is uncertain.

EPA's new Cancer Guidelines and Supplemental Guidance (March 2005) will be used as the basis for EPA's analysis of all new carcinogenicity risk assessments. If updated carcinogenicity risk assessments become available, EPA will determine whether an evaluation should be conducted as part of the remedial design to assess whether adjustments to the target cleanup levels for this remedial action are needed in order for this remedy to remain protective of human health.

a. Groundwater Compliance Monitoring Levels

The contaminated groundwater at the Site is within either: the Waste Management Area for TP-1, TP-2, and TP-3 or the technical impracticability zone for the Underground Workings. Therefore, federal and State groundwater cleanups standards are utilized as action-specific ARARs for the purpose of monitoring and evaluating the remedial actions. Groundwater under the CF-2 lead cover adjacent to TP-3, although not contaminated, will also be monitored using these standards to assess the protectiveness of the cover remedy. Site groundwater outside these areas meets federal and State drinking water standards and is available for unrestricted use, but monitoring will be conducted to make sure that contaminants exceeding drinking water standards or any background levels that may be determined during the design stage do not migrate from the Waste Management Areas or the Underground Workings.

Compliance levels have been established for groundwater for all COCs identified in the Baseline Risk Assessment found to pose an unacceptable risk to either public health or the environment. Compliance levels have been set based on the ARARs (e.g., federal and state MCLs, federal non-zero MCLGs and more stringent State standards) as available, or other suitable criteria described below. Periodic assessments of the protection afforded by remedial actions will be made as the remedy is being implemented and at the completion of the remedial action.

Where a promulgated State standard is more stringent than values established under the federal Safe Drinking Water Act or federal risk-based standards, the State standard is used as the compliance level. In the absence of an MCLG, an MCL, a proposed MCLG, proposed MCL, a more stringent State standard, or other suitable criteria to be considered (*e.g.*, health advisory, state guideline), a compliance level was derived for each COC having carcinogenic potential (Classes A, B, and C compounds) based on a 10^{-6} excess cancer risk level per compound considering the current or future ingestion of groundwater from domestic water usage. In the absence of the above standards and criteria, compliance levels for all other COCs (Classes D and E) were established based on a level that represents an acceptable exposure level to which the human population including sensitive subgroups may be exposed without adverse affect during a lifetime or part of a lifetime, incorporating an adequate margin of safety (hazard quotient = 1) considering the current or future ingestion of groundwater from domestic water usage.

Table 90 below summarizes the compliance monitoring levels for groundwater.

Table 90
Groundwater Compliance Monitoring Levels

Chemicals of Concern	Compliance Monitoring Level (ug/l)	Basis
Arsenic	10	MCL
Barium	2,000	MCL/MCLG
Cadmium	5	MCL/MCLG
Lead	15	VPGWES
Manganese	840	VPGWES
Mercury	2	MCL
Nickel	100	VPGES
Thallium	2	MCL/MCLG
Vanadium	89	Risk based
Zinc	3130	Risk based

All Groundwater Compliance Monitoring Levels identified in the ROD and newly promulgated ARARs and modified ARARs that call into question the protectiveness of the remedy and the protective levels determined as a consequence of the risk assessment of residual contamination must be met for groundwater outside the Waste Management Areas, the Underground Workings, and the CF-2 lead cover area. The values represent concentration levels that cannot be exceeded in any given well location outside of the Waste Management Areas, the Underground Workings, or the CF-2 lead cover area without triggering a reassessment of the protectiveness of the remedy and potentially requiring remedy modification.

b. Soil Cleanup Levels

The only COC for soil is lead. The cleanup level for soil contaminated with lead will be 400 mg/kg. A concentration of 400 mg/kg or less in soil would protect over 95% of the exposed child population based on the use of the IEUBK model.

c. Surface Water Cleanup Levels

The cleanup level for surface water will be the federal Clean Water Act and Vermont Water Quality Standards for a Class B surface water. These standards contain both numerical and biological criteria that should be me and are listed below in Table 91.

Table 91
Surface Water Cleanup Levels

Contaminant of Concern	Surface water cleanup level (ug/l)	Basis
Cadmium	1.13*	Vermont Water Quality Standards
Copper	11.8*	Vermont Water Quality Standards
Iron	1,000	Vermont Water Quality Standards
Lead	3.18*	Vermont Water Quality Standards
Nickel	158*	Vermont Water Quality Standards
Selenium	5	Vermont Water Quality Standards
Zinc	106*	Vermont Water Quality Standards

* Denotes COC whose cleanup level is based on the hardness of the receiving water. The cleanup levels are based on a hardness of 100 mg/l. If the hardness of the receiving water is greater than 100 mg/l, the cleanup level will be adjusted accordingly, as allowed by the regulation. Vermont Water Quality Standards, Appendix C (Nat. Res. Brd, Water Res. P. 12-004-052)

M. STATUTORY DETERMINATIONS

The remedial action selected for implementation at the Elizabeth Mine Superfund Site is consistent with CERCLA and, to the extent practicable, the NCP. The selected remedy is protective of human health and the environment, will comply with ARARs, except for when waived, and is cost-effective. In addition, the selected remedy utilizes permanent solutions and alternate treatment technologies or resource recovery technologies to the maximum extent practicable. To a limited extent, due to the complexity of the remedy and size of the Site, the remedy is able to partially satisfy the statutory preference for treatment that permanently and significantly reduces the mobility, toxicity or volume of hazardous substances as a principal element.

1. The Selected Remedy is Protective of Human Health and the Environment

The remedy at this Site will adequately protect human health and the environment by eliminating, reducing or controlling exposures to human and environmental receptors through treatment, engineering controls, monitoring, and institutional controls (i.e., land use restrictions).

The selected remedy will reduce potential human health risk levels such that they do not exceed EPA's acceptable risk range of 10^{-4} to 10^{-6} for incremental carcinogenic risk, and such that the non-carcinogenic hazard is below a level of concern. It will reduce potential human health risk levels to protective ARARs levels, *i.e.*, the remedy will comply with ARARs and To Be Considered criteria. Implementation of the selected remedy will not pose any unacceptable short-term risks or cause any cross-media impacts.

There are no human health threats associated with the LBSA, SED, and IA components of the Site. The LBSA is a threat to aquatic ecological receptors in the unnamed tributaries to Lord Brook and Lord Brook. The selected alternative, LBSA 4, will abate the ecological threat by removal of TP-4 and the primary ARD generating area of the South Mine. LBSA 4 will also fill and cover the primary ARD generating area at the South Open Cut and control the discharge from the South Open Cut. These actions should result in the protection of downstream ecological resources. Alternatives SED 2 and IA 4 rely upon the success of the NTCRA and other remedial cleanup actions at the Site to achieve the protection of the environment. SED 2 relies upon the successful implementation of the NTCRA and LBSA 4 to eliminate the source of contamination for the sediments. Once the source loading has been eliminated, then the sediments should recover through natural scour and dispersion processes. IA 4 relies upon the success of the NTCRA (for TP-1 and TP-2) to reduce the loading to Copperas Brook. Both SED 2 and IA 4 will include monitoring programs to document the effectiveness of the cleanup in achieving the response objectives. IA 4 will also rely upon institutional controls to prevent the exposure of waste rock that could cause additional ARD. Alternative CF-4 and SW-2 address threats to human health. CF-4 will protect human health and the environment by preventing direct contact and ingestion of lead contaminated soil. A soil cover, monitoring, and the associated institutional controls will prevent future (post Remedial Action) contact with lead contaminated soil. SW-2 will implement a groundwater monitoring program and institutional controls to prevent installation of drinking water wells in locations that could draw contamination from the Underground Workings or TP-1, TP-2, TP-3. The groundwater monitoring will also monitor the groundwater around the CF-2 soil cover below TP-3. SW-2 will also include institutional controls to protect the NTCRA, TCRA, and Remedial Action.

2. The Selected Remedy Complies With ARARs

The selected remedy (consisting of partial consolidation and discharge from source areas at LBSA; covering of lead-impacted soils at CF; monitored natural recovery at SED; monitoring and institution controls at IA; and monitoring, operation and maintenance of NTCRA and TCRA components, and institutional controls at SW) will comply with all federal and any more stringent state ARARs that pertain to the remedial actions (see Tables 92 thru 96). In making this determination, EPA has made the following specific findings:

- Pursuant to regulations under the federal Clean Water Act, 40 CFR Part 230, Subpart B, EPA has made a determination that Alternatives LBSA 4, CF 2, and SED 2 are the least damaging practicable alternatives with respect to potential wetland impacts;

- Pursuant to Section 106 of the NHPA, EPA has determined that impacts to historic resources in the Lord Brook Source Area and at the Upper and Lower Copperas Factories are unavoidable in order to protect human health and the environment and that the monitoring and institutional control alternative for the WWII Infrastructure area will avoid any impacts to historic resources;

- EPA is invoking a Statutory Waiver of the ARARs, under CERCLA, relating to groundwater for the water within the Underground Workings covered under SW-2. EPA has determined that it would be technically impracticable from an engineering perspective to achieve federal Safe Drinking Water MCLs, MCLGs, or Vermont Primary Groundwater Quality Standards for the water contained within the Underground Workings of the Elizabeth Mine. This waiver applies to all of the inorganic constituents that are present in the naturally occurring material at the Site and specifically to cadmium, copper, manganese, mercury, and nickel which have been detected in the groundwater of the Underground Workings at concentrations above either MCLs, MCLGs, or the Vermont Primary Groundwater Quality Standards. The primary basis for this finding is that the source of the contamination, the wall rock and waste rock within the Underground Workings, will generate the condition that causes the water to exceed the standards for hundreds, if not thousands of years. While it would be practicable to collect and treat the discharge from the Underground Workings or to prevent the spread of the contamination from the Underground Workings into the adjacent aquifer, EPA has determined that there are no practicable actions that would result in the water within the Underground Workings consistently achieving groundwater standards. EPA retains the Federal MCLs, MCLGs, and Vermont Primary Groundwater Quality Standards as compliance criteria for the groundwater at the edge of the Technical Impracticability Zone, which is the aquifer surrounding the Underground Workings. The Technical Impracticability Zone is shown on Figure 23. EPA has determined that contaminated water within the Underground Workings is not causing the adjacent bedrock aquifer to exceed federal or state drinking water or groundwater standards. Therefore the selected remedy incorporating this waiver is protective of human health and the environment as long as land use controls are implemented to prevent drinking water wells from being installed that would draw water from the Underground Workings. A more detailed discussion of the Technical impracticability waiver can be found in Appendix D of the Feasibility Study; and

- Pursuant to federal drinking water and Vermont groundwater standards, groundwater under the Waste Management Units (the tailing piles covered under the NTCRA and TCRA) do not have to achieve groundwater cleanup standards.

Federal chemical-, location-, and action-specific ARARs, and the areas they apply to, are listed as follows:

Chemical-specific

1. **Clean Water Act and Ambient Water Quality Criteria Regulations** – Lord Brook Source Areas, LBSA-4; Impacted Sediment, SED-2

Location-specific

1. **Protection of Wetlands, Executive Order 11990** - Lord Brook Source Areas, LBSA-4; Upper and Lower Copperas Factories, CF-4; Impacted Sediment, SED-2; WWII-Era Infrastructure Area, IA-4; Site-wide Groundwater, SW-2
2. **Clean Water Act, Section 404 and Wetlands Protection Regulations** – Lord Brook Source Areas, LBSA-4; Upper and Lower Copperas Factories, CF-4; Impacted Sediment, SED-2; WWII-Era Infrastructure Area, IA-4; Site-wide Groundwater, SW-2
3. **Fish and Wildlife Coordination Act** - Lord Brook Source Areas, LBSA-4; Upper and Lower Copperas Factories, CF-4; Impacted Sediment, SED-2; WWII-Era Infrastructure Area, IA-4; Site-wide Groundwater, SW-2
4. **Floodplain Management, Executive Order 11988** – Impacted Sediment, SED-2
5. **National Historic Preservation Act** - Lord Brook Source Areas, LBSA-4; Upper and Lower Copperas Factories, CF-4; Impacted Sediment, SED-2; WWII-Era Infrastructure Area, IA-4; Site-wide Groundwater, SW-2
6. **Archeological and Historic Preservation Act** - Lord Brook Source Areas, LBSA-4; Upper and Lower Copperas Factories, CF-4; Impacted Sediment, SED-2; WWII-Era Infrastructure Area, IA-4; Site-wide Groundwater, SW-2

Action-specific

1. **Clean Water Act and National Pollution Discharge Elimination System Regulations-** Lord Brook Source Areas, LBSA-4 (construction activities, water discharge, and monitoring); Upper and Lower Copperas Factories, CF-4 (construction activities and monitoring); Impacted Sediment, SED-2 and Site-wide Groundwater, SW-2 (monitoring); WWII-Era Infrastructure Area, IA-4 (monitoring and institutional controls)
2. **Clean Water Act and Stormwater Regulations** - Lord Brook Source Areas, LBSA-4; Upper and Lower Copperas Factories, CF-4
3. **Clean Water Act and Groundwater Injection Standards Regulations** - Lord Brook Source Areas, LBSA-4
4. **Surface Mining Control and Reclamation Act** - Lord Brook Source Areas, LBSA-4
5. **Resource Conservation and Recovery Act** - Upper and Lower Copperas Factories, CF-4
6. **Safe Drinking Water Act and National Primary Drinking Water Regulations** - Site-wide Groundwater, SW-2 (standards waived for groundwater in the Underground Workings and do not apply to groundwater under the waste management area)

The ARARs for each area vary depending on factors that include, but are not limited to, whether the remedy involves treatment, consolidation, covering, and/or monitoring; the location of the area relative to wetlands, floodplains, and historic structures; and the contaminants present (including acid mine drainage, lead) (see Tables 92 thru 96).

In addition, the selected remedies for each area will comply with the following more stringent state ARARs that are described in more detail in Tables 92 thru 96:

Chemical-specific

1. **Vermont Water Quality Standards** - Lord Brook Source Areas, LBSA-4; Impacted Sediment, SED-2

Location-specific

1. **Vermont Wetlands Act and Wetland Rules** - Lord Brook Source Areas, LBSA-4; Upper and Lower Copperas Factories, CF-4; Impacted Sediment, SED-2; WWII-Era Infrastructure Area, IA-4
2. **Vermont Land Use and Development Law** - Lord Brook Source Areas, LBSA-4; Upper and Lower Copperas Factories, CF-4; Impacted Sediment, SED-2; WWII-Era Infrastructure Area, IA-4; Site-wide Groundwater, SW-2
3. **Vermont Regulation of Stream Flow** - Lord Brook Source Areas, LBSA-4; Upper and Lower Copperas Factories, CF-4; Impacted Sediment, SED-2
4. **Vermont Endangered Species Law** - Lord Brook Source Areas, LBSA-4

Action-specific

1. **Vermont Water Pollution Control Act and Water Quality Standards** - Lord Brook Source Areas, LBSA-4 (water discharge, construction activities, and monitoring); Upper and Lower Copperas Factories, CF-4 (construction activities and monitoring); Impacted Sediment, SED-2 (monitoring); WWII-Era Infrastructure Area, IA-4 (monitoring and institutional controls)
2. **Vermont Stormwater Management Act and Stormwater Management Rule** - Lord Brook Source Areas, LBSA-4; Upper and Lower Copperas Factories, CF-4; Impacted Sediment, SED-2; WWII-Era Infrastructure Area, IA-4; Site-wide Groundwater, SW-2
3. **Vermont Dam Statute** - Lord Brook Source Areas, LBSA-4
4. **Vermont Underground Injection Control Rule** - Lord Brook Source Areas, LBSA-4
5. **Vermont Air Pollution Control Act and Air Pollution Control Regulations** - Lord Brook Source Areas, LBSA-4; Upper and Lower Copperas Factories, CF-4
6. **Vermont Hazardous Waste Management Act and Hazardous Waste Management Regulations** - Upper and Lower Copperas Factories, CF-4
7. **Vermont Solid Waste Management Rules** - Site-wide Groundwater, SW-2
8. **Vermont Groundwater Protection Act and Groundwater Protection Rule and Strategy** - Site-wide Groundwater, SW-2 (standards waived for groundwater in the Underground Workings and do not apply to groundwater under the waste management area)

The specific State ARARs for each area are listed in Tables 92 thru 96 and, as with the federal ARARs, vary based on factors that include, but are not limited to, whether the remedy involves treatment, consolidation, covering, and/or monitoring; the location of the area relative to wetlands, floodplains, and historic structures; and the contaminants present (including acid mine drainage, lead).

The following federal and State policies, advisories, criteria, and guidances (TBCs) were also be considered for the selected remedy for each of the five areas listed in Tables 92 thru 96.

Chemical-specific

1. **EPA National Recommended Water Quality Criteria** - Lord Brook Source Areas, LBSA-4; Impacted Sediment, SED-2
2. **EPA Risk Reference Dose** - Lord Brook Source Areas, LBSA-4; Upper and Lower Copperas Factories, CF-4; Impacted Sediment, SED-2; WWII-Era Infrastructure Area, IA-4; Site-wide Groundwater, SW-2
3. **EPA Carcinogen Assessment Group, Cancer Slope Factors** - Lord Brook Source Areas, LBSA-4; Upper and Lower Copperas Factories, CF-4; Impacted Sediment, SED-2; WWII-Era Infrastructure Area, IA-4; Site-wide Groundwater, SW-2
4. **EPA Residential Risk Based Concentrations (Region III) and Preliminary Remediation Goal, Residential (Region IX)** - Upper and Lower Copperas Factories, CF-4
5. **EPA OSWER Directive: Clarification to the 1994 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities** - Upper and Lower Copperas Factories, CF-4
6. **EPA Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems** - Impacted Sediment, SED-2
7. **EPA Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments**- Impacted Sediment, SED-2
8. EPA Health Advisory for Manganese – SW-2

Action-specific

1. **Vermont Handbook for Erosion Prevention and Sediment Control** - Lord Brook Source Areas, LBSA-4; Upper and Lower Copperas Factories, CF-4; Impacted Sediment, SED-2; WWII-Era Infrastructure Area, IA-4; Site-wide Groundwater, SW-2
2. **EPA Specifications for Geotechnical Analysis for Review of Dike Stability** - Lord Brook Source Areas, LBSA-4

3. The Selected Remedy is Cost-Effective

In EPA's judgment, the selected remedy is cost-effective because the remedy's costs are proportional to its overall effectiveness (see 40 CFR 300.430(f)(1)(ii)(D)). This determination was made by evaluating the overall effectiveness of those alternatives that satisfied the threshold criteria (i.e., that are protective of human health and the environment and comply with all federal and any more stringent State ARARs, or as appropriate, waive specific ARARs). Overall effectiveness was evaluated by assessing three of the five balancing criteria – long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness – in combination. The overall effectiveness of each alternative then was compared to the alternative's costs to determine cost-effectiveness. The relationship of the overall effectiveness of the remedial alternatives selected in this ROD were determined to be proportional to its costs and hence represents a reasonable value for the money to be spent. The alternatives selected for Remedial Action were each the least cost alternatives for the alternatives considered for that area.

Alternative LBSA 4 is the least expensive of the alternatives that would reliably achieve ARARs and the remedial action objectives for the Lord Brook Source Area. LBSA 4 does not provide the same level of permanence as LBSA 3. However, LBSA 3 has an estimated cost that is almost twice that of LBSA 4 and there are potentially substantial short-term impacts associated with LBSA 3 due to the very large quantity of fill required to fill the South Open Cut. LBSA 4 will achieve a similar level of ARAR compliance and long-term effectiveness for less cost that LBSA 3. Alternative CF 4 has the least cost of the protective and ARAR compliant alternatives for the Upper and Lower Copperas Factories. CF 2 and CF 3 would have a higher level of permanence than CF 4, however, CF 2 is twice the cost and CF 3 is almost four times the cost of CF 4. CF 4 can reliably achieve protection of human health and compliance with ARAR for a lower cost. Alternative SED 2 is the least expensive of the alternatives that would reliably achieve ARARs and remedial action objectives for the Impacted Sediments. SED 3 would be permanent, but at ten times the cost and having the potential for substantial short-term impacts to excavate the sediments and restore the impacted habitant. SED 2 was determined to be the least damaging practicable alternative under the Clean Water Act. Alternative IA 4 is the least expensive alternative that would reliably achieve ARARs and remedial action objectives for the World War II –Era Infrastucture Area. This alternative is five to ten times less costly than the other two alternatives. SW-2 is the least costly and only alternative that would comply with ARARs and achieve remedial action objectives for the site wide groundwater.

4. The Selected Remedy Utilizes Permanent Solutions and Alternative Treatment or Resource Recovery Technologies to the Maximum Extent Practicable

Once the Agency identified those alternatives that attain or, as appropriate, waive ARARs, and that are protective of human health and the environment, EPA identified which alternative utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. This determination was made by deciding which one of the identified alternatives provides the best balance of trade-offs among alternatives in terms of: (1) long-term effectiveness and permanence; (2) reduction of toxicity, mobility or volume through treatment; (3) short-term effectiveness; (4) implementability; and (5) cost. The balancing test emphasized long-term effectiveness and permanence and the reduction of toxicity, mobility and volume through treatment, and considered the preference for treatment as a principal element, the bias against off-site land disposal of untreated waste, and community and state acceptance. The selected remedy provides the best balance of trade-offs among the alternatives.

The selected Alternatives LBSA 4, CF 4, SED 2, IA 4, and SW 2 provide the best balance of the five balancing criteria and other factors taken into consideration. They are each the least expensive alternative that achieves protection of public health and the environment and complies with ARARs. None of these alternatives use treatment as a primary element to achieve any reduction of toxicity, mobility, or volume. For Alternatives LBSA 4 and CF 4, containment of the waste was determined to be the most cost-effective approach to achieve long-term effectiveness and permanence. Short-term impacts associated with historic resources and community input to preserve the historic features were taken into consideration. Alternatives SED 2 and IA 4 are dependent upon the success of the NTCRA and LBSA to achieve long-term effectiveness and permanence. The long-term monitoring will document that the protectiveness is met. SW-2 is unique in that the primary objective is to document that groundwater contamination does not extend beyond the current delineation of the Waste Management Area or Technical Impracticability Zone. Maintenance of the NTCRA, TCRA and remedial components along with monitoring and institutional controls will provide the long-term effectiveness.

5. The Selected Remedy Satisfies the Preference for Treatment Which Permanently and Significantly Reduces the Toxicity, Mobility or Volume of the Hazardous Substances as a Principal Element

The proposed remedy is not able to satisfy the preference for treatment due to the extensive area of Site contamination and the complexity of addressing site risks. For the majority of the waste at the Elizabeth Mine, engineering controls (covers and diversion) along with land use restrictions are the primary components of the selected remedy. None of these alternatives use treatment as a primary element to achieve the reduction of toxicity, mobility, or volume. Some level of treatment will occur through the application of alkalinity to the mine waste to prevent acid generation and the increase in the water level of the South Open Cut pit lake to submerge exposed sulfur bearing bedrock. In addition, the NTCRA includes collection and treatment of the seeps of TP-1.

6. Five-Year Reviews of the Selected Remedy are Required

Because this remedy will result in hazardous substances remaining on-site above levels that will not allow for unlimited use and unrestricted exposure, a review will be conducted within five years after initiation of the remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

N. DOCUMENTATION OF NO SIGNIFICANT CHANGES

On July 11, 2006, EPA presented a proposed plan that described the cleanup proposal for the Elizabeth Mine. EPA reviewed all written and verbal comments submitted during the public comment period, which was open from July 11 to August 11, 2006. It was determined that no significant changes to the remedy, as originally identified in the proposed plan, were necessary.

O. STATE ROLE

The State of Vermont Department of Environmental Conservation (Vermont DEC) has reviewed the various alternatives and has indicated its support for the selected remedy. The State has also reviewed the Remedial Investigation, Risk Assessment and Feasibility Study with respect to the Site to determine whether the selected remedy is in compliance with applicable or relevant and appropriate State environmental and facility siting laws and regulations. The State of Vermont concurs with the selected remedy for the Elizabeth Mine Superfund Site. A copy of the declaration of concurrence is attached as Appendix B.

APPENDIX A

TABLES AND FIGURES NOT IN ROD TEXT

Record of Decision Tables

TABLE 1
METALS AND INORGANIC CONSTITUENTS
IN TP-3 SURFACE SOILS

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Cadmium	3.28	30	6	0.094	15.4
Copper	625	30	26	309	14,400
Lead	400	50	12	5.1	100,000
Molybdenum	87.5	30	4	3	165
Selenium	4.37	22	18	0.8	82
Zinc	545	30	3	64.7	905

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 2
METALS AND INORGANIC CONSTITENTS
IN TP-3 SUBSURFACE SOILS

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Cadmium	3.28	43	13	2	26
Copper	625	43	30	31	70,000
Molybdenum	87.5	43	2	2	95
Zinc	545	43	8	29	2,650

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 3
METALS AND INORGANIC CONSTITUENTS
IN TP-1 AND TP-2 SURFACE SOILS

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Cadmium	3.28	37	5	0.07	40.1
Copper	625	37	11	31.7	3,190
Selenium	4.37	37	23	0.7	29
Thallium	4.98	37	1	0.14	90
Zinc	545	37	5	23	8,580

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

Table 4
METALS AND INORGANIC CONSTITUENTS
IN TP-1 AND TP-2 SUBSURFACE SOILS

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Cadmium	3.28	60	42	3	120
Copper	625	60	52	17	8,090
Selenium	4.37	60	33	20	60
Thallium	4.98	48	8	40	80
Zinc	545	60	54	29	5,650

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 5
METALS AND INORGANIC CONSTITUENTS
IN LOWER COPPERAS BROOK SURFACE SOILS

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	625	30	6	24	2,060
Selenium	4.37	30	14	0.12	10.4

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 6
METALS AND INORGANIC CONSTITUENTS
IN WWII-ERA INFRASTRUCTURE AREA SURFACE SOILS

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	625	11	11	1,200	6,090
Selenium	4.37	11	7	3.5	40

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 7
METALS AND INORGANIC CONSTITUENTS IN TP-3 AND UPPER COPPERAS BROOK SURFACE WATER SAMPLING LOCATIONS

Constituent	PRG µg/l	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration µg/l	Maximum Detected Concentration µg/l
Aluminum	87	56	54	85.1	145,000
Beryllium	4	56	6	0.61	4.4
Cadmium	1.13	56	48	2.3	153
Copper	11.8	56	50	2	104,000
Iron	1,000	56	53	250	747,000
Lead	3.18	56	22	0.28	30.6
Mercury	0.012	55	3	0.12	0.62
Nickel	158	56	40	1.2	574
Selenium	5	56	9	2.4	13.4
Silver	4.06	56	5	0.057	20.7
Thallium	1.7	56	30	0.086	47.6
Zinc	106	56	47	2.2	20,500

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Water Quality Standards and EPA Nationally Recommended Water Quality Criteria)

TABLE 8
METALS AND INORGANIC CONSTITUENTS IN THE TP-1 SEEPS (AQUEOUS SAMPLES)

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Aluminum	87	9	7	75.7	11,600
Cadmium	1.13	9	1	7.1	7.1
Copper	11.8	9	4	200	2,080
Iron	1,000	9	7	35.4	812,000
Lead	3.18	9	4	10	21.1
Selenium	5	9	1	1.4	7.6
Zinc	106	9	5	19	1,210

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Water Quality Standards and EPA Nationally Recommended Water Quality Criteria)

TABLE 9
METALS AND INORGANIC CONSTITUENTS
IN LOWER COPPERAS BROOK
SURFACE WATER SAMPLING LOCATIONS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Aluminum	87	54	45	79.5	19,000
Cadmium	1.13	54	37	0.4	22.2
Copper	11.8	54	44	1	12,500
Iron	1,000	54	43	56.2	434,000
Lead	3.18	54	9	1.7	6
Mercury	0.012	54	5	0.058	0.13
Selenium	5	54	3	1.2	10.6
Silver	4.06	54	1	0.62	7.3
Thallium	1.7	54	13	0.11	53
Zinc	106	54	43	2.5	3,400

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Water Quality Standards and EPA Nationally Recommended Water Quality Criteria)

TABLE 10
METALS AND INORGANIC CONSTITUENTS
IN WWII-ERA INFRASTRUCTURE AREA
SURFACE WATER SAMPLING LOCATIONS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Aluminum	87	14	11	42.3	9,380
Cadmium	1.13	14	4	0.4	5.8
Copper	11.8	14	11	2.7	7,550
Iron	1,000	14	12	507	203,000
Lead	3.18	14	1	8.2	8.2
Mercury	0.012	14	2	0.13	0.14
Selenium	5	14	1	3.7	8
Silver	4.06	14	1	0.063	5.4
Thallium	1.7	14	1	19.1	19.1
Zinc	106	14	9	50.4	710

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Water Quality Standards and EPA Nationally Recommended Water Quality Criteria)

TABLE 11
LOADING RATES
COPPERAS BROOK WATERSHED

Parameter	Loading Rate, Dissolved-Phase (kg/day) and pH (SU)				
	Copperas Brook at TP-3 (SW-501)	Copperas Brook below TP-1/TP-2 (SW-509)	Tailing Fan Seep Flow (SW-516)	Copperas Brook below Tailing Fan/Seep Flow (SW-517)	Outlet to WBOR (SW-520)
Flow Rate (cfs)	0.05	0.57	0.11	0.71	0.87
pH	2.82	3.29	3.64	3.32	3.51
Sulfate (total)	211	533	726	734	1,248
Aluminum	11.8	18.3	3.2	23.8	22.3
Calcium	11.2	69.7	108.3	130.2	212.0
Cadmium	0.017	0.022	0.002	0.026	0.022
Copper	10.6	12.3	0.14	14.2	12.1
Iron	29.7	68.8	116.6	89.7	156.9
Zinc	2.4	3.5	0.19	3.7	3.3

Note: kg/day = kilograms per day

TABLE 12
LOADING RATES
WWII-ERA INFRASTRUCTURE AREA

Parameter	Loading Rate, Dissolved-Phase (kg/day) and pH (SU)		
	1898 Adit (SW-503)	TP-1 Access Road Drainage (SW-505)	Copperas Brook Outlet to WBOR (SW-520)
Flow Rate (cfs)	0.01	0.06	0.87
pH	6.02	5.06	3.51
Aluminum	ND	0.17	22.3
Cadmium	ND	0.0002	0.022
Copper	ND	0.11	12.1
Iron	0.0004	0.023	156.9
Zinc	0.0017	0.032	3.3

Note: ND indicates that the analyte was not detected; therefore there is no associated mass load contribution.

TABLE 13
METALS AND INORGANIC CONSTITUENTS
IN TP-3 SEDIMENT

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	149	2	3	748	841
Selenium	0.94	2	2	9.5	12.8

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

Record of Decision Tables

TABLE 14
METALS AND INORGANIC CONSTITUENTS
IN THE TP-1 AREA SEDIMENT SAMPLING LOCATIONS

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	149	3	3	251	500
Selenium	0.94	4	3	10.9	11

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 15
METALS AND INORGANIC CONSTITUENTS
IN WWII-ERA INFRASTRUCTURE AREA SEDIMENT

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	149	3	2	684	13,800
Zinc	260	3	1	214	285

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 16
METALS AND INORGANIC CONSTITUENTS
IN LOWER COPPERAS BROOK SEDIMENT

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	149	16	12	38.7	437
Selenium	0.94	21	8	0.068	11.8
Silver	3.7	16	1	0.036	4

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 17
METALS AND INORGANIC CONSTITUENTS
IN TP-3 SHALLOW OVERBURDEN GROUNDWATER MONITORING WELLS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Cadmium	5	2	2	40.3	57.1
Copper	1,300	2	2	4,120	15,200
Manganese	840	2	2	6,620	10,100
Nickel	100	2	2	160	295

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Primary Groundwater Quality Standards and EPA Safe Drinking Water Act Maximum Contaminant Levels (MCLs))

TABLE 18
METALS AND INORGANIC CONSTITUENTS
IN TP-3 TILL GROUNDWATER MONITORING WELLS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Cadmium	5	8	1	0.2	10
Manganese	840	8	3	7.1	4,400
Nickel	100	8	1	10	118

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Primary Groundwater Quality Standards and EPA Safe Drinking Water Act Maximum Contaminant Levels (MCLs))

TABLE 19
METALS AND INORGANIC CONSTITUENTS
IN TP-3 BEDROCK GROUNDWATER MONITORING WELLS

Constituent	RPG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Arsenic	10	17	3	4	81.7
Beryllium	4	17	5	8.7	22.5
Cadmium	5	20	12	0.1	1,200
Chromium	100	20	6	8.3	285
Copper	1,300	17	8	573	448,000
Lead	15	17	4	1.8	99.7
Manganese	840	17	10	6.5	26,400
Nickel	100	17	9	594	4,640
Thallium	2	20	2	1.1	1,000

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Primary Groundwater Quality Standards and EPA Safe Drinking Water Act Maximum Contaminant Levels (MCLs))

TABLE 20
METALS AND INORGANIC CONSTITUENTS IN TP-1
SHALLOW OVERBURDEN GROUNDWATER SAMPLING POINTS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Cadmium	5	10	4	0.2	411
Copper	1,300	10	1	138	6,460
Lead	15	10	3	17.1	215
Manganese	840	10	7	11.1	28,400
Nickel	100	10	2	28.4	399

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Primary Groundwater Quality Standards and EPA Safe Drinking Water Act Maximum Contaminant Levels (MCLs))

TABLE 21
METALS AND INORGANIC CONSTITUENTS
IN WWII-ERA INFRASTRUCTURE AREA
SHALLOW OVERBURDEN GROUNDWATER MONITORING WELL

Constituent	RPG (µg/l)	Total Number of Samples	Total Number of Exceedances	Detected Concentration in Monitoring Well MW-19A (µg/l)
Cadmium	5	1	1	7.3
Copper	1,300	1	1	1,350
Manganese	840	1	1	4,300

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Primary Groundwater Quality Standards and EPA Safe Drinking Water Act Maximum Contaminant Levels (MCLs))

TABLE 22
METALS AND INORGANIC CONSTITUENTS
IN SOUTH MINE SURFACE SOILS

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Cadmium	3.28	19	3	0.3	12.3
Copper	625	19	13	41.6	6,900
Manganese	3,326	19	3	96.1	3,890
Selenium	4.37	19	7	1.2	14.7
Zinc	545	19	6	112	3,400

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 23
METALS AND INORGANIC CONSTITUENTS
IN SOUTH OPEN CUT SURFACE SOILS

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	625	16	4	104	2,400
Selenium	4.37	16	2	0.2	7.7

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 24
METALS AND INORGANIC CONSTITUENTS
IN TP-4 SURFACE SOILS

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	625	8	7	349	2,020
Selenium	4.37	8	2	0.9	9.2

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 25
METALS AND INORGANIC CONSTITUENTS
IN SOUTH MINE/SOUTH OPEN CUT/TP-4 COMBINED DRAINAGE
SURFACE SOILS

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Cadmium	3.28	13	1	0.29	6.67
Copper	625	13	2	28.6	886
Zinc	545	13	1	88	705

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 26
METALS AND INORGANIC CONSTITUENTS
IN SOUTH MINE SURFACE WATER SAMPLING LOCATIONS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Aluminum	87	8	6	158	3,400
Cadmium	1.13	8	6	1.1	3.7
Copper	11.8	8	7	113	1,208
Iron	1,000	8	4	187	14,000
Mercury	0.012	8	2	0.02	0.02
Zinc	106	8	7	264	819.6

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria) PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Water Quality Standards and EPA Nationally Recommended Water Quality Criteria)

TABLE 27
METALS AND INORGANIC CONSTITUENTS
IN SOUTH OPEN CUT SURFACE WATER SAMPLING LOCATIONS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Aluminum	87	16	16	140	24,800
Cadmium	1.13	16	12	0.11	8.1
Copper	11.8	16	15	3.3	4,670
Iron	1,000	16	15	260	15,600
Lead	3.18	16	2	0.32	43.7
Mercury	0.012	16	3	0.03	0.11
Nickel	158	16	1	4.1	180
Zinc	106	16	4	33.4	1,240

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Water Quality Standards and EPA Nationally Recommended Water Quality Criteria)

TABLE 28
METALS AND INORGANIC CONSTITUENTS
IN TP-4 SURFACE WATER SAMPLING LOCATIONS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Aluminum	87	11	11	670	14,000
Cadmium	1.13	11	10	0.25	8.5
Copper	11.8	11	10	5.5	2,470
Iron	1,000	11	3	140	10,000
Lead	3.18	11	4	0.41	45.1
Mercury	0.012	11	3	0.02	0.2
Selenium	5	11	1	0.3	5
Zinc	106	11	10	68.5	840

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Water Quality Standards and EPA Nationally Recommended Water Quality Criteria)

TABLE 29
METALS AND INORGANIC CONSTITUENTS
IN SOUTH MINE/SOUTH OPEN CUT/TP-4 COMBINED DRAINAGE
SURFACE WATER SAMPLING LOCATIONS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Aluminum	87	4	1	1,740	1,740
Cadmium	1.13	4	1	1.1	1.4
Copper	11.8	4	3	93.2	628
Zinc	106	4	3	130	339

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Water Quality Standards and EPA Nationally Recommended Water Quality Criteria)

TABLE 30
METALS AND INORGANIC CONSTITUENTS
IN LORD BROOK DOWNGRADIENT OF SITE DRAINAGES
SURFACE WATER SAMPLING LOCATIONS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Aluminum	87	29	11	20.1	355
Cadmium	1.13	29	1	0.067	1.2
Copper	11.8	29	10	0.97	208
Mercury	0.012	29	1	0.1	0.1
Thallium	1.7	29	1	4.1	4.1
Zinc	106	29	2	1.5	171

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Water Quality Standards and EPA Nationally Recommended Water Quality Criteria)

TABLE 31
MASS LOADING RATES
SOUTH MINE AND SOUTH OPEN CUT/TP-4 SUBDRAINAGE AREAS

	Loading Rate (grams per day)			
	South Mine (SW-10)		South Open Cut/TP-4 (SW-310)	
Constituent	Total Fraction	Dissolved Fraction	Total Fraction	Dissolved Fraction
Aluminum	0	0	1,180	1,130
Cadmium	0.3	0.2	0.5	0.4
Cobalt	0.6	0.7	17.8	17.8
Copper	26	22	337	320.7
Manganese	4.7	4.0	129	126
Nickel	2.1	1.7	17.4	16.6
Zinc	61	60	111	105.7

TABLE 32
MASS LOADING RATES TO LORD BROOK
SOUTH MINE AND SOUTH OPEN CUT/TP-4 DRAINAGE

	Mass Load to Lord Brook from South Mine/South Open Cut/TP-4 (grams/day)	
Constituent	Total Fraction	Dissolved Fraction
Aluminum	(see note)	504
Cadmium	1.0	0.7
Cobalt	21	22
Copper	426	402
Nickel	24	23
Manganese	154	151
Zinc	228	221

TABLE 33
METALS AND INORGANIC CONSTITUENTS
IN SOUTH OPEN CUT SEDIMENT

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Cadmium	4.98	2	1	9.45	9.45
Copper	149	2	2	3,220	4,560

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 34
METALS AND INORGANIC CONSTITUENTS
IN SOUTH MINE SEDIMENT

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	149	5	5	149	2,350
Manganese	1,100	5	1	230	2,410
Nickel	48.6	5	2	28	81
Selenium	0.94	5	4	1.2	2.2
Zinc	260	5	4	222	557

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 35
METALS AND INORGANIC CONSTITUENTS
IN TP-4 SEDIMENT

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Chromium	111	7	1	41.1	151
Copper	149	7	7	484	2,750
Nickel	48.6	7	1	12	50
Selenium	0.94	7	6	1.5	10

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 36
METALS AND INORGANIC CONSTITUENTS
IN SOUTH MINE/SOUTH OPEN CUT/TP-4 COMBINED DRAINANGE SEDIMENT SAMPLES

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	149	2	2	341	487

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 37
METALS AND INORGANIC CONSTITUENTS
IN LORD BROOK SEDIMENT SAMPLES

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	149	14	1	8.3	209

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 38
METALS AND INORGANIC CONSTITUENTS
IN SARGENT BROOK WATERSHED SURFACE SOILS

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Cadmium	3.28	42	2	0.11	17.8
Copper	625	42	12	10.2	2,700
Selenium	4.37	42	4	0.1	29.3
Zinc	545	42	5	30	1,600

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 39
METALS AND INORGANIC CONSTITUENTS
IN SARGENT BROOK SURFACE WATER SAMPLING LOCATIONS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Aluminum	87	25	11	23	1,160
Cadmium	1.13	25	2	0.27	2.1
Copper	11.8	25	2	1.2	55
Iron	1,000	25	4	14.3	546,000
Lead	3.18	25	2	0.19	7.7
Mercury	0.012	25	1	0.02	0.02
Silver	4.06	25	3	0.69	12.2
Thallium	1.7	25	4	3.5	18.2
Zinc	106	25	2	1.4	162

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Water Quality Standards and EPA Nationally Recommended Water Quality Criteria)

TABLE 40
METALS AND INORGANIC CONSTITUENTS
IN SARGENT BROOK SEDIMENT SAMPLES

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Manganese	1,100	13	1	200	1,600

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 41
METALS AND INORGANIC CONSTITUENTS
IN MINE POOL ACCESS AREA SURFACE SOILS

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	625	10	2	15.3	930
Zinc	545	10	1	48	908

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria)

TABLE 42
METALS AND INORGANIC CONSTITUENTS IN FURNACE FLATS SURFACE SOILS

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Cadmium	3.28	30	1	0.19	7.3
Copper	625	30	21	54	10,600
Lead	400	30	1	8.3	574
Selenium	4.37	30	10	0.22	19.4
Zinc	545	30	4	57	990

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria

TABLE 43
METALS AND INORGANIC CONSTITUENTS IN ARTESIAN VENT AND WBOR SURFACE WATER SAMPLING LOCATIONS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Artesian Vent					
Aluminum	87	46	46	346	6,130
Cadmium	1.13	46	28	0.93	3.7
Copper	11.8	46	46	77.8	421
Iron	1,000	46	46	2,990	77,400
Mercury	0.012	46	4	0.073	0.12
Selenium	5	24	2	2	16.9
Thallium	1.7	46	12	3.7	32.8
Zinc	106	46	44	37.9	861
WBOR -- Artesian Vent to Copperas Brook					
Aluminum	87	106	60	35.4	18,200
Cadmium	1.13	106	2	0.4	2.8
Copper	11.8	106	26	0.8	1,500
Iron	1,000	106	24	43	21,500
Lead	3.18	53	2	1.18	18.2
Mercury	0.012	106	8	0.11	0.22
Thallium	1.7	106	4	4.6	4.7
Zinc	106	106	6	1.2	411

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Water Quality Standards and EPA Nationally Recommended Water Quality Criteria)

TABLE 44
METALS AND INORGANIC CONSTITUENTS
IN WBOR DOWNSTREAM OF FURNACE FLATS
SURFACE WATER SAMPLING LOCATIONS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Aluminum	87	27	14	35.4	3,250
Cadmium	1.13	27	1	2.8	2.8
Copper	11.8	27	6	0.8	1,500
Iron	1,000	27	5	43	14,400
Lead	3.18	27	1	1.18	6.5
Mercury	0.012	27	3	0.14	0.22
Thallium	1.7	27	1	4.7	4.7
Zinc	106	27	1	2.1	411

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Water Quality Standards and EPA Nationally Recommended Water Quality Criteria)

TABLE 45
METALS AND INORGANIC CONSTITUENTS
IN WBOR MIXING ZONE SURFACE WATER SAMPLING LOCATIONS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Aluminum	87	74	67	32.9	17,500
Cadmium	1.13	74	6	0.53	3.1
Copper	11.8	74	55	2.1	1,410
Iron	1,000	74	61	36.3	97,300
Lead	3.18	74	11	1.56	17.3
Mercury	0.012	74	8	0.1	0.63
Selenium	5	74	1	1.5	6.9
Thallium	1.7	74	3	3.3	4.3
Zinc	106	74	15	1.4	539

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Water Quality Standards and EPA Nationally Recommended Water Quality Criteria)

TABLE 46
METALS AND INORGANIC CONSTITUENTS DOWNGRADIENT OF THE WBOR MIXING ZONE SURFACE WATER SAMPLING LOCATIONS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Aluminum	87	72	44	13	1,710
Copper	11.8	72	28	2.6	42
Iron	1,000	72	21	127	5,140
Lead	3.18	72	2	1.6	3.7
Mercury	0.012	72	6	0.052	0.22
Selenium	5	72	1	2.4	5.5
Thallium	1.7	72	6	2.9	7.1
Zinc	106	72	3	1.8	1,810

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Water Quality Standards and EPA Nationally Recommended Water Quality Criteria)

TABLE 47
METALS AND INORGANIC CONSTITUENTS OMPOMPANOOSUC RIVER SURFACE WATER SAMPLING LOCATIONS

Constituent	PRG (µg/l)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (µg/l)	Maximum Detected Concentration (µg/l)
Aluminum	87	27	17	41.6	919
Copper	11.8	27	7	0.72	59.6
Iron	1,000	27	2	80	1,790
Lead	3.18	27	1	2.3	4.4
Thallium	1.7	27	2	4.9	5.9

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria – primarily Vermont Water Quality Standards and EPA Nationally Recommended Water Quality Criteria)

TABLE 48
METALS AND INORGANIC CONSTITUENTS IN SEDIMENT SAMPLES WBOR BETWEEN ARTESIAN VENT AND COPPERAS BROOK

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	149	20	2	5.7	268

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria

TABLE 49
METALS AND INORGANIC CONSTITUENTS IN WBOR MIXING ZONE SEDIMENT

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	149	17	5	5	348
Selenium	0.94	17	3	3.1	3.5

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria

TABLE 50
BASE METAL CONCENTRATIONS IN SEDIMENTS IN THE WBOR
WBOR MIXING ZONE

Constituent	Sample Location and Concentrations (mg/kg)											
	Upstream Samples		Mixing Zone Samples									
	SD 309	LOC 10	LOC 11	LOC 12	LOC 13	LOC 14	LOC 16	LOC 17	LOC 19	LOC 21	LOC 23	SD 307
Cadmium	0.167	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.299
Copper	5.9	8.4	116	175	212	7.1	26.4	85.7	48.7	28.9	29.5	51.7
Iron	7,710	6,010	29,000	27,500	43,100	7,480	6,600	12,800	7,060	6,310	11,100	11,900
Zinc	22.7	10.9	57.4	61.1	117	29.9	34.7	60.8	38.8	32.8	44.9	39.7

Note: ND = Not detected above laboratory detection limit.

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria

TABLE 51
CONCENTRATIONS OF SELECTED METALS IN SEDIMENT
LOWER REACH OF WBOR
JULY 2000

Constituent	Concentration (mg/kg)			
	LOC-25	LOC-26	LOC-27	LOC-28
Aluminum	8,080	11,200	12,100	6,180
Copper	45.9	46.7	98.0	37.0
Iron	12,300	15,700	23,500	9,470
Zinc	57.4	66.6	102	42.1

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria

TABLE 52
METALS AND INORGANIC CONSTITUENTS
IN OMPOMPANOOSUC AND CONNECTICUT RIVER SEDIMENT

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	149	46	18	4.1	529
Manganese	1,100	46	12	134	3,790
Nickel	48.6	46	3	5.2	50.7
Selenium	0.94	46	3	1.8	2.1
Zinc	260	46	8	34.3	309

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria

TABLE 53
METALS AND INORGANIC CONSTITUENTS
IN CONNECTICUT RIVER SUBSURFACE SEDIMENT

Constituent	PRG (mg/kg)	Total Number of Samples	Total Number of Exceedances	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)
Copper	149	34	30	42.3	701
Manganese	1,100	34	21	597	1,750
Nickel	48.6	34	22	34	62.7
Selenium	0.94	34	7	1.4	2.3
Zinc	260	34	27	86.7	500

PRG – Preliminary Remediation Goals (based on ecological and human health screening criteria

Record of Decision Tables

Table 54
Current and Future Potential use of Site

	Current On-Site Use	Current Adjacent Use	Reasonable Potential Beneficial Use of Site	Basis for Potential Beneficial Use of Site	Time Frame to Achieve Potential Beneficial Use
Land	Abandoned mining site and undeveloped forest	residential/ recreational	recreational/ historic preservation/educational	Town redevelopment assessment and restrictions placed by private property owners	Upon completion of NTCRA and Remedial Action; and implementation of land use restrictions to protect remaining components of the NTCRA and remedial action (capped tailing piles, wells, and water control structures)
Shallow Groundwater	none	none	Limited due to expected low yield	Private property development limited by institutional controls (i.e.deed restrictions) for areas of the capped tailing piles and underground workings	Upon completion of NTCRA and Remedial Action; and implementation of land use restrictions to prevent groundwater use in areas of the capped tailing piles and underground workings; unrestricted elsewhere on the Site
Deep Groundwater	none	drilled wells for water supply	unrestricted except in areas (tailing piles and underground workings) where land use restrictions will prevent use in perpetuity	Private property development limited by institutional controls (i.e.deed restrictions) for areas of the capped tailing piles and underground workings	Upon completion of NTCRA and Remedial Action; and implementation of land use restrictions to prevent groundwater use in areas of the capped tailing piles and underground workings; unrestricted elsewhere on the Site
Surface Water	Limited, some unauthorized swimming in the pool in the South Open Cut	Downstream - fishing, swimming	Fishing, swimming (access will be prohibited to the pool that will be expanded in the south open cut as part of the remedy)	Private property development limited by institutional controls (i.e. deed restrictions) for the pit lake at the South Open Cut.	Upon completion of NTCRA and Remedial Action and restoration of water quality in the Site's waterways; also upon implementation of land use restrictions to prevent use of the pit lake at the South Open Cut

Table 55 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations								
Scenario Timeframe: Current **Medium:** Soil **Exposure Medium:** Soil								
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Units**	**Frequency of Detection**	**Exposure Point Concentration**	**Exposure Point Concentration Units**	**Statistical Measure**
		Min	**Max**					
Soil On-site - Direct Contact at Copperas Factories Hotspot	Lead	5.1	100,0000	Mg/kg	21/21	6,534	Mg/kg	average
Key Mg/kg: milligram per kilogram is the same as ppm: Parts per million 95% UCL: 95% Upper Confidence Limit								

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in soil (*i.e.*, the concentration that will be used to estimate the exposure and risk from each COC in the soil). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was derived. The table indicates that lead is the only COC in soil at the site. The arithmetic mean was used as the exposure point concentration for lead as recommended in EPA's Integrated Exposure and Uptake Biokinetic Model (IUEBK) model for assessing exposure to lead.

Table 56
Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Future

Medium: Groundwater

Exposure Medium: Groundwater

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Ingestion of groundwater from TP-1/TP-2	Arsenic	25.9	25.9	Ug/l	1/16	25.9	ug/l	Max
	Barium	3.8	3540	Ug/l	12/16	3540	Ug/l	Max
	Cadmium	0.37	558	Ug/l	12/16	558	Ug/l	Max
	Manganese	3.2	29,000	Ug/l	16/16	29,000	Ug/l	Max
	Nickel	26	1,710	Ug/l	10/16	1,710	Ug/l	Max
	Thallium	13.9	13.9	Ug/l	1/16	13.9	Ug/l	Max
	Vanadium	5.8	1,310	Ug/l	11/16	1,310	Ug/l	Max
	Zinc	34.7	189,000	Ug/l	11/16	189,000	Ug/l	Max

Key

ppm: Parts per million

95% UCL: 95% Upper Confidence Limit

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in the groundwater beneath and adjacent to TP-1 and TP-2(*i.e.*, the concentration that will be used to estimate the exposure and risk from each COC in the groundwater). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was derived. The table indicates that manganese, cadmium, barium, vanadium, and zinc are the most frequently detected COCs in groundwater for this area of the Site. Due to the limited amount of sample data available, the maximum concentration was used as the default exposure point concentration.

Table 57 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations								
Scenario Timeframe: Future **Medium:** Groundwater **Exposure Medium:** Groundwater								
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Units**	**Frequency of Detection**	**Exposure Point Concentration**	**Exposure Point Concentration Units**	**Statistical Measure**
		Min	**Max**					
Ingestion of groundwater – from TP-3 area	Arsenic	0.6	78.5	Ug/l	7/28	78.5	Ug/l	Max
	Cadmium	0.1	1,250	Ug/l	20/31	1,250	Ug/l	Max
	Manganese	8	26,700	Ug/l	27/28	26,700	Ug/l	Max
	Nickel	20	4,610	Ug/l	17/28	4,610	Ug/l	Max
	Thallium	0.05	8.3	Ug/l	10/31	8.3	Ug/l	Max
	Vanadium	2.6	1,050	Ug/l	18/30	1,050	Ug/l	Max
	Zinc	10	128	Ug/l	16/28	128	Ug/l	Max

Key:

ppm: Parts per million

95% UCL: 95% Upper Confidence Limit

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in groundwater beneath and adjacent to TP-3(*i.e.*, the concentration that will be used to estimate the exposure and risk from each COC in the groundwater). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was derived. The table indicates that manganese, cadmium, vanadium, nickel, and zinc are the most frequently detected COCs in groundwater for this area of the Site. Due to the limited amount of sample data available, the maximum concentration was used as the default exposure point concentration.

Record of Decision Tables

Table 58								
Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations								
Scenario Timeframe: Future **Medium:** Groundwater **Exposure Medium:** Groundwater								
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Units**	**Frequency of Detection**	**Exposure Point Concentration**	**Exposure Point Concentration Units**	**Statistical Measure**
		Min	**Max**					
Ingestion of groundwater from underground workings	Cadmium	0.4	88.3	Ug/l	3/5	88.3	Ug/l	Max
	Manganese	167	3,030	Ug/l	5/5	3,030	Ug/l	Max
	Mercury	0.5	10.2	Ug/l	2/5	10.2	Ug/l	Max
	Zinc	804	16,200	Ug/l	3/5	16,200	Ug/l	Max

Key

ppm: Parts per million

95% UCL: 95% Upper Confidence Limit

MAX: Maximum Concentration

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in groundwater for the underground workings(*i.e.*, the concentration that will be used to estimate the exposure and risk from each COC in the groundwater). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was derived. The table indicates that manganese, cadmium, and zinc are the most frequently detected COCs in groundwater for this area of the Site. Due to the limited amount of sample data available, the maximum concentration was used as the default exposure point concentration.

Record of Decision Tables

Table 59
Cancer Toxicity Data Summary

Pathway: Ingestion, Dermal – groundwater and soil

Chemical of Concern	Oral Cancer Slope Factor	Dermal Cancer Slope Factor	Slope Factor Units	Weight of Evidence/Cancer Guideline Description	Source	Date (MM/DD/YYYY)
Arsenic	1.5		Kg-day/mg	A	IRIS	10/19/2005
Lead	---			B2	IRIS	10/19/2005

Key

— : No information available

IRIS: Integrated Risk Information System, U.S. EPA

EPA Group:

A - Human carcinogen

B1 - Probable human carcinogen - Indicates that limited human data are available

B2 - Probable human carcinogen - Indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as a human carcinogen

E - Evidence of noncarcinogenicity

Summary of Toxicity Assessment

This table provides carcinogenic risk information which is relevant to the contaminants of concern in both soil and ground water. At this time, slope factors are not available for the dermal route of exposure. Thus, the dermal slope factors used in the assessment have been extrapolated from oral values. An adjustment factor is sometimes applied, and is dependent upon how well the chemical is absorbed via the oral route. Adjustments are particularly important for chemicals with less than 50% absorption via the ingestion route. However, adjustment is not necessary for the chemicals evaluated at this site. Therefore, the same values presented above were used as the dermal carcinogenic slope factors for these contaminants.

None of the COCs are also considered carcinogenic via the inhalation route.

Table 60
Non-Cancer Toxicity Data Summary

Pathway: Ingestion, Dermal

Chemical of Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Dermal RfD	Dermal RfD Units	Primary Target Organ	Combined Uncertainty /Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (MM/DD/YYYY)
Arsenic	chronic	0.0003	Mg/kg-day	0.0003	Mg/kg -day	Keratosis (skin)	3/1	IRIS	10/19/2005
Barium	chronic	0.2	Mg/kg-day	0.014	Mg/kg -day	Kidney	300/1	IRIS	10/19/2005
Cadmium	chronic	0.00005	Mg/kg-day	0.0000125	Mg/kg -day	Renal cortex	10/1	IRIS	10/19/2005
Lead						CNS/PNS			
Manganese	chronic	0.14	Mg/kg-day	0.0056	Mg/kg -day	CNS	1/1	IRIS	10/19/2005
Nickel	chronic	0.02	Mg/kg-day	0.0008	Mg/kg -day	Decreased body weight	300/1	IRIS	10/19/2005
Thallium	chronic	0.00008	Mg/kg-day	0.00008	Mg/kg -day	NOAEL	3000/1	IRIS	12/21/2005
Vanadium	chronic	0.009	Mg/kg-day	0.000234	Mg/kg -day	Decreased hair cysteine	100/1	IRIS	10/19/2005
Zinc	chronic	0.3	Mg/kg-day	0.3	Mg/kg -day	Red blood cells	3/1	IRIS	10/19/2005

Pathway: Inhalation

Chemical of Concern	Chronic/ Subchronic	Inhalation RfC	Inhalation RfC Units	Inhalation RfD	Inhalation RfD Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfC:RfD: Target Organ	Dates (MM/DD/YYYY)
Lead	chronic	—	—	—	—	—	—	IRIS	10/19/2005

Key

—: No information available

IRIS: Integrated Risk Information System, U.S. EPA

Summary of Toxicity Assessment

This table provides non-carcinogenic risk information which is relevant to the contaminants of concern in both soil and ground water. Eight of the COCs have toxicity data indicating their potential for adverse non-carcinogenic health effects in humans. The chronic toxicity data available all eight for oral exposures, have been used to develop oral reference doses (RfDs). As was the case for the carcinogenic data, dermal RfDs can be extrapolated from the oral RfDs applying an adjustment factor as appropriate. At this time, inhalation reference concentrations are not available for any of the COCs.

Table 61
Risk Characterization Summary – Carcinogens

Scenario Timeframe: Current

Receptor Population: Resident

Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk				
				Ingestion	Inhalation	Dermal	External (Radiation)[1]	Exposure Routes Total
Groundwater	Groundwater	Ingestion of contaminated water from TP-1/TP-2	Arsenic	3.6×10^{-4}	N/A	6	—	3.6×10^{-4}
							Groundwater risk total=	**3.6×10^{-4}**
Ground Water	Ground Water	Ingestion of contaminated water from TP-3	Arsenic	7.2×10^{-4}	—		—	7.2×10^{-4}
							Ground-water risk total=	**7.2×10^{-4}**

Key

— : Toxicity criteria are not available to quantitatively address this route of exposure.

N/A: Route of exposure is not applicable to this medium.

Risk Characterization

This table provides risk estimates for the significant routes of exposure. These risk estimates are based on a reasonable maximum exposure and were developed by taking into account various conservative assumptions about the frequency and duration of an adult's exposure to ground water, as well as the toxicity of the COC (arsenic). The total risk from direct exposure to contaminated ground water at this site to a current adult resident is estimated to range from 3.6×10^{-4}, if the adult consumed water from a drinking water well in the area of contaminated groundwater surrounding TP-1/TP-2 or 7.2×10^{-4} if the adult consumed groundwater from a future drinking water supply located near TP-3. The only COC contributing to this risk level is arsenic in ground water. This risk level indicates that if no clean-up action is taken, an individual would have an increased probability of 7.2 in 10,000 or 3.6 in 10,000 of developing cancer as a result of site-related exposure to the COCs.

Table 62 **Risk Characterization Summary – Carcinogens**								
Scenario Timeframe: Current **Receptor Population:** Resident **Receptor Age:** Child								
Medium	**Exposure Medium**	**Exposure Point**	**Chemical of Concern**	**Carcinogenic Risk**				
				Ingestion	**Inhalation**	**Dermal**	**External (Radiation)**[1]	**Exposure Routes Total**
Groundwater	Groundwater	Ingestion of contaminated water from TP-1/TP-2	Arsenic	3.2×10^{-4}	N/A	6	—	3.2×10^{-4}
							Groundwater risk total=	**3.6 x 10-4**
Ground Water	Ground Water	Ingestion of contaminated water from TP-3	Arsenic	7.2×10^{-1}	—		—	6.3×10^{-1}
							Ground-water risk total=	**6.3×10^{-4}**

Key

— : Toxicity criteria are not available to quantitatively address this route of exposure.

N/A: Route of exposure is not applicable to this medium.

1--This column would be used in the event that one of the contaminants of concern was a radionuclide. If there are no radionuclides associated with a particular site, then this column can be deleted.

Risk Characterization

This table provides risk estimates for the significant routes of exposure. These risk estimates are based on a reasonable maximum exposure and were developed by taking into account various conservative assumptions about the frequency and duration of a child's exposure to ground water, as well as the toxicity of the COC (arsenic). The total risk from direct exposure to contaminated ground water at this site to a current child resident is estimated to range from 3.2×10^{-1} if the child consumed water from a drinking water well in the area of contaminated groundwater surrounding TP-1/TP-2 or6.3×10^{-4} if the child consumed groundwater from a future drinking water supply located near TP-3. The only COC contributing to this risk level is arsenic in ground water. This risk level indicates that if no clean-up action is taken, an individual would have an increased probability of 6.3 in 10,000 or 3.2 in 10,000 of developing cancer as a result of site-related exposure to the COCs.

Table 63 Risk Characterization Summary - Non-Carcinogens								
Scenario Timeframe: Current **Receptor Population:** Resident **Receptor Age:** Child								
Medium	**Exposure Medium**	**Exposure Point**	**Chemical of Concern**	**Primary Target Organ**	**Non-Carcinogenic Hazard Quotient**			
					Ingestion	**Inhalation**	**Dermal**	**Exposure Routes Total**
Ground water	Ground Water	Contaminated water from TP-1/TP-2	Arsenic	Skin	8.28			8.38
			Barium	Kidney	1.7			1.7
			Cadmium	Renal cortex/kidney	107.01		6.22	113.23
			Lead	CNS/PNS				
			Manganese	CNS	115.87		4.21	120.08
			Nickel	Descreased body weight	8.2			8.2
			Thallium	NOEL	16.66			16.66
			Vanadium	Decreased hair cysteine	13.96			13.96
			Zinc	Red blood cells	6.04			6.04
Ground-Water Hazard Index Total =								288
Receptor Hazard Index =								288
Maximum Tissue-Specific Hazard Index =								115

Key

— : Toxicity criteria are not available to quantitatively address this route of exposure.

N/A: Route of exposure is not applicable to this medium.

CNS/PNS: Central Nervous System/Peripheral Nervous System

NOEL: No Observed Effect Level

Risk Characterization

This table provides hazard quotients (HQs) for each route of exposure and the hazard index (sum of hazard quotients) for all routes of exposure. The Risk Assessment Guidance (RAGS) for Superfund states that, generally, a hazard index (HI) greater than 1 indicates the potential for adverse noncancer effects. The estimated HI of 288 indicates that the potential for diverse noncancer effects could occur from exposure to contaminated groundwater containing arsenic, cadmium, manganese, nickel, thallium, vanadium, and zinc. The maximum tissue-specific hazard index is 115 for effects of barium and cadmium on kidney. The noncancer risk from exposure to lead in ground water was assessed using the IEUBK model.

Table 64
Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Current

Receptor Population: Resident

Receptor Age: **Adult**

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Ground water	Ground Water	Contaminated water from TP-1/TP-2	Arsenic	Skin	1.89			1.89
			Cadmium	Renal cortex/kidney	24.46		2.75	27.12
			Manganese	CNS	26.48		1.86	28.34
			Nickel	Decreased body weight	1.87			1.87
			Thallium	NOEL	3.81			3.81
			Vanadium	Decreased hair cysteine	3.19			3.19
Ground-Water Hazard Index Total =								66.3
Receptor Hazard Index =								66
Maximum Tissue-Specific Hazard Index =								28

Key

— : Toxicity criteria are not available to quantitatively address this route of exposure.

N/A: Route of exposure is not applicable to this medium.

CNS: Central Nervous System

NOEL: No Observed Effect Level

Risk Characterization

This table provides hazard quotients (HQs) for each route of exposure and the hazard index (sum of hazard quotients) for all routes of exposure. The Risk Assessment Guidance (RAGS) for Superfund states that, generally, a hazard index (HI) greater than 1 indicates the potential for adverse noncancer effects. The estimated HI of indicates that the potential for adverse noncancer effects could occur from exposure to contaminated groundwater containing arsenic, cadmium, manganese, nickel, thallium, vanadium, and zinc. The noncancer risk from exposure to lead in ground water was assessed using the IEUBK model.

Table 65
Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Current

Receptor Population: Resident

Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Ground water	Ground Water	Contaminated water from TP-3	Arsenic	Skin	16.38			16.38
			Cadmium	Renal cortex/kidney	207.32		12.04	219.36
			Manganese	CNS	98.49		3.58	99.07
			Nickel	Decreased body weight	22.1			22.1
			Thallium	NOEL	9.95			9.95
			Vanadium	Decreased hair cycteine	11.19			11.19
			Zinc	Red blood cells	35.75			35.75
							Ground-Water Hazard Index Total =	416.8
							Receptor Hazard Index =	417
							Maximum Tissue-Specific Hazard Index =	219

Key

— : Toxicity criteria are not available to quantitatively address this route of exposure.

N/A: Route of exposure is not applicable to this medium.

CNS: Central Nervous System

NOEL: No Observed Effect Level

Risk Characterization

This table provides hazard quotients (HQs) for each route of exposure and the hazard index (sum of hazard quotients) for all routes of exposure. The Risk Assessment Guidance (RAGS) for Superfund states that, generally, a hazard index (HI) greater than 1 indicates the potential for adverse noncancer effects. The estimated HI of indicates that the potential for adverse noncancer effects could occur from exposure to contaminated groundwater containing arsenic, cadmium, manganese, nickel, thallium, vanadium, and zinc. The noncancer risk from exposure to lead in ground water was assessed using the IEUBK model.

Table 66
Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Current

Receptor Population: Resident

Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Ground water	Ground Water	Contaminated water from TP-3	Arsenic	Skin	3.74			3.74
			Cadmium	Renal cortex/kidney	47.39		5.33	52.72
			Manganese	CNS	22.51		1.58	24.09
			Nickel	Decreased body weight	5.05			5.05
			Thallium	NOEL	2.27			2.27
			Vanadium	Decreased hair cysteine	2.56			2.56
			Zinc	Red blood cells	8.17			8.17
							Ground-Water Hazard Index Total =	98.6
							Receptor Hazard Index =	99
							Maximum Tissue-Specific Hazard Index =	53

Key
— : Toxicity criteria are not available to quantitatively address this route of exposure.

N/A: Route of exposure is not applicable to this medium.

CNS: Central Nervous System

NOEL: No Observed Effect Level

Risk Characterization

This table provides hazard quotients (HQs) for each route of exposure and the hazard index (sum of hazard quotients) for all routes of exposure. The Risk Assessment Guidance (RAGS) for Superfund states that, generally, a hazard index (HI) greater than 1 indicates the potential for adverse noncancer effects. The estimated HI of 99 indicates that the potential for adverse noncancer effects could occur from exposure to contaminated groundwater containing arsenic, cadmium, manganese, nickel, thallium, vanadium, and zinc. The noncancer risk from exposure to lead in ground water was assessed using the IEUBK model.

Table 67
Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Current

Receptor Population: Resident

Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient			
					Ingestion	Inhalation	Dermal	Exposure Routes Total
Ground water	Ground Water	Contaminated water from underground workings	Cadmium	Renal cortex /kidney	8.54			8.54
			Manganese	CNS	11.15			11.5
			Mercury	Kidney/ autoimmune	1.71			1.71
			Zinc	Red blood cells	2.72			2.72
							Ground-Water Hazard Index Total =	24.5
							Receptor Hazard Index =	25
							Maximum Tissue-Specific Hazard Index =	12

Key
— : Toxicity criteria are not available to quantitatively address this route of exposure.

N/A: Route of exposure is not applicable to this medium.

CNS: Central Nervous System

Risk Characterization

This table provides hazard quotients (HQs) for each route of exposure and the hazard index (sum of hazard quotients) for all routes of exposure. The Risk Assessment Guidance (RAGS) for Superfund states that, generally, a hazard index (HI) greater than 1 indicates the potential for adverse noncancer effects. The estimated HI of indicates that the potential for adverse noncancer effects could occur from exposure to contaminated groundwater containing cadmium, manganese, mercury, and zinc. The noncancer risk from exposure to lead in ground water lead was assessed using the IEUBK model.

Table 68 Risk Characterization Summary - Non-Carcinogens								
Scenario Timeframe: Current **Receptor Population:** Resident **Receptor Age:** Adult								
Medium	**Exposure Medium**	**Exposure Point**	**Chemical of Concern**	**Primary Target Organ**	**Non-Carcinogenic Hazard Quotient**			
					Ingestion	**Inhalation**	**Dermal**	**Exposure Routes Total**
Ground water	Ground Water	Contaminated water from underground workings	Cadmium	Renal cortex/ kidney	1.95			1.95
			Manganese	CNS	2.6			2.6
Ground-Water Hazard Index Total =								4.6
Receptor Hazard Index =								5
Maximum Tissue-Specific Hazard Index =								5

Key
— : Toxicity criteria are not available to quantitatively address this route of exposure.

N/A: Route of exposure is not applicable to this medium.

CNS: Central Nervous System

Risk Characterization

This table provides hazard quotients (HQs) for each route of exposure and the hazard index (sum of hazard quotients) for all routes of exposure. The Risk Assessment Guidance (RAGS) for Superfund states that, generally, a hazard index (HI) greater than 1 indicates the potential for adverse noncancer effects. The estimated HI of indicates that the potential for adverse noncancer effects could occur from exposure to contaminated groundwater containing cadmium and manganese. The noncancer risk from exposure to lead in ground water was assessed using the IEUBK model.

Table 69

Summary of Chemicals of Concern and

Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current

Medium: Surface Water (Total Fraction)

Exposure Medium: Surface Water

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Lord Brook	Aluminum	20.1	355	µg/l	15/30	102	µg/l	Mean
						127		95% UCL
	Chromium	0.61	10.00	µg/l	4/30	1.3	µg/l	Mean
						1.8		95% UCL
	Cobalt	0.94	13	µg/l	8/30	1.9	µg/l	Mean
						2.6		95% UCL
	Copper	0.97	208	µg/l	25/30	25.4	µg/l	Mean
						37.5		95% UCL
	Cyanide	5.3	5.3	µg/l	1/11	2.5	µg/l	Mean
						3.0		95% UCL
	Iron	18.1	367	µg/l	16/30	82	µg/l	Mean
						111		95% UCL
	Lead	1.6	2.80	µg/l	4/30	1.2	µg/l	Mean
						1.3		95% UCL
	Manganese	2.2	103	µg/l	27/30	18	µg/l	Mean
						25.1		95% UCL
	Nickel	1.7	15	µg/l	13/30	7.3	µg/l	Mean
						10.0		95% UCL
	Silver	ND	ND	µg/l	0/30	0.4	µg/l	Mean
						0.4		95% UCL

Key

µg/l: micrograms per liter is the same as ppb: Parts per billion

95% UCL: 95% Upper Confidence Limit

WBOR: West Branch of the Ompompanoosuc River

MAX: Maximum Concentration

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in surface water (*i.e.*, the concentration that will be used to estimate the exposure and risk from each COC in surface water). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was derived.

Table 70
Summary of Chemicals of Concern and
Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current
Medium: Surface Water (Total Fraction)
Exposure Medium: Surface Water

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
WBOR Downstream of Mixing Zone	Aluminum	13	1500	µg/l	44/61	248	µg/l	Mean
						306		95% UCL
	Chromium	0.47	5.9	µg/l	17/61	1.2	µg/l	Mean
						1.5		95% UCL
	Cobalt	1	1.5	µg/l	6/61	2.44	µg/l	Mean
						3.69		95% UCL
	Copper	2.7	42.0	µg/l	53/61	14.7	µg/l	Mean
						17.6		95% UCL
	Cyanide	5.4	19.0	µg/l	3/22	3.1	µg/l	Mean
						4.5		95% UCL
	Iron	127	5130	µg/l	57/61	890	µg/l	Mean
						1099		95% UCL
	Lead	1.6	3.7	µg/l	10/61	1.3	µg/l	Mean
						1.5		95% UCL
	Manganese	3.6	400	µg/l	60/61	39	µg/l	Mean
						50		95% UCL
	Nickel	0.83	3.9	µg/l	11/61	3.2	µg/l	Mean
						4.5		95% UCL
	Silver	ND	ND	µg/l	0/61	10	µg/l	Surrogate

Key

µg/l: micrograms per liter is the same as ppb: Parts per billion

95% UCL: 95% Upper Confidence Limit

WBOR: West Branch of the Ompompanoosuc River

MAX: Maximum Concentration

ND: No Detections

Mean: Arithmetic Mean

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in surface water (*i.e.*, the concentration that will be used to estimate the exposure and risk from each COC in surface water). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was derived.

Table 71
Summary of Chemicals of Concern and
Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current
Medium: Surface Water (Total Fraction)
Exposure Medium: Surface Water

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Copperas Brook	Aluminum	109	16400	µg/l	47/47	9550	µg/l	Mean
						10457		95% UCL
	Chromium	1.3	90.5	µg/l	47/47	8.9	µg/l	Mean
						12.0		95% UCL
	Cobalt	8.7	342.0	µg/l	47/47	104.9	µg/l	Mean
						121.1		95% UCL
	Copper	3.1	10500	µg/l	47/47	2484	µg/l	Mean
						3081		95% UCL
	Cyanide	5.5	13.0	µg/l	14/14	5.0	µg/l	Mean
						6.3		95% UCL
	Iron	468	492000	µg/l	47/47	204491	µg/l	Mean
						241739		95% UCL
	Lead	1.7	14.3	µg/l	47/47	2.8	µg/l	Mean
						3.6		95% UCL
	Manganese	58.7	9150	µg/l	47/47	3179	µg/l	Mean
						3665		95% UCL
	Nickel	1	83.1	µg/l	45/45	36.8	µg/l	Mean
						41.8		95% UCL
	Silver	0.068	7.8	µg/l	46/46	1.3	µg/l	Mean
						1.7		95% UCL

Key

µg/l: micrograms per liter is the same as ppb: Parts per billion

95% UCL: 95% Upper Confidence Limit

WBOR: West Branch of the Ompompanoosuc River

MAX: Maximum Concentration

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in surface water (*i.e.*, the concentration that will be used to estimate the exposure and risk from each COC in surface water). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was derived.

Table 72

Summary of Chemicals of Concern and

Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current

Medium: Surface Water (Total Fraction)

Exposure Medium: Surface Water

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Upper Copperas Brook	Aluminum	85.1	134000	µg/l	33/34	42220	µg/l	Mean
						51746		95% UCL
	Chromium	0.58	173.0	µg/l	29/34	56.5	µg/l	Mean
						70.3		95% UCL
	Cobalt	13.6	2310	µg/l	28/34	860	µg/l	Mean
						1089		95% UCL
	Copper	2	101000	µg/l	32/34	30422	µg/l	Mean
						38099		95% UCL
	Cyanide	ND	ND	µg/l	0/8	NC	µg/l	NA
	Iron	741	747000	µg/l	33/34	114304	µg/l	Mean
						156506		95% UCL
	Lead	1.6	30.6	µg/l	24/34	9.0	µg/l	Mean
						11.6		95% UCL
	Manganese	3.5	6010	µg/l	33/34	2102	µg/l	Mean
						2611		95% UCL
	Nickel	1.2	530.0	µg/l	29/34	196.5	µg/l	Mean
						238.2		95% UCL
	Silver	0.068	20.7	µg/l	12/34	2.0	µg/l	Mean
						3.0		95% UCL

Key

µg/l: micrograms per liter is the same as ppb: Parts per billion

95% UCL: 95% Upper Confidence Limit

WBOR: West Branch of the Ompompanoosuc River

MAX: Maximum Concentration

ND: No Detections

NC: Not Calculated

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in surface water (*i.e.*, the concentration that will be used to estimate the exposure and risk from each COC in surface water). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was derived.

Table 73

Summary of Chemicals of Concern and

Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current

Medium: Surface Water (Total Fraction)

Exposure Medium: Surface Water

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Tributaries to Lord Brook	Aluminum	158	24800	µg/l	21/24	5204	µg/l	Mean
						6850		95% UCL
	Chromium	1.5	27.20	µg/l	11/24	4.5	µg/l	Mean
						6.6		95% UCL
	Cobalt	2.6	223	µg/l	23/24	73.1	µg/l	Mean
						89.9		95% UCL
	Copper	113	4670	µg/l	23/24	1543.6	µg/l	Mean
						1891.9		95% UCL
	Cyanide	ND	ND	µg/l	0/10	3.5	µg/l	Mean
						4.1		95% UCL
	Iron	187	15600	µg/l	19/24	2077	µg/l	Mean
						3137		95% UCL
	Lead	1.7	43.70	µg/l	8/24	3.6	µg/l	Mean
						6.5		95% UCL
	Manganese	20.5	1720	µg/l	24/24	622	µg/l	Mean
						795.6		95% UCL
	Nickel	9	180	µg/l	23/24	64.7	µg/l	Mean
						82.5		95% UCL
	Silver	0.036	0.04	µg/l	1/24	0.3	µg/l	Mean
						0.4		95% UCL

Key

µg/l: micrograms per liter is the same as ppb: Parts per billion

95% UCL: 95% Upper Confidence Limit

WBOR: West Branch of the Ompompanoosuc River

MAX: Maximum Concentration

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in surface water (*i.e.*, the concentration that will be used to estimate the exposure and risk from each COC in surface water). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was derived.

Table 74

Summary of Chemicals of Concern and

Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current

Medium: Surface Water (Total Fraction)

Exposure Medium: Surface Water

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
WBOR Mixing Zone	Aluminum	32.9	17500	µg/l	64/68	1607	µg/l	Mean
						2231		95% UCL
	Chromium	0.49	84.5	µg/l	33/68	5.0	µg/l	Mean
						7.9		95% UCL
	Cobalt	0.8	67.70	µg/l	38/68	7.38	µg/l	Mean
						9.69		95% UCL
	Copper	3.1	1290	µg/l	55/68	138.9	µg/l	Mean
						186.3		95% UCL
	Cyanide	5.8	69.0	µg/l	4/20	6.8	µg/l	Mean
						12.3		95% UCL
	Iron	36.3	63800	µg/l	66/68	9637	µg/l	Mean
						12592		95% UCL
	Lead	1.56	17.3	µg/l	22/68	2.3	µg/l	Mean
						2.9		95% UCL
	Manganese	14	2640	µg/l	67/68	277	µg/l	Mean
						366		95% UCL
	Nickel	1.2	60.6	µg/l	39/68	6.6	µg/l	Mean
						8.7		95% UCL
	Silver	0.56	2	µg/l	7/68	1	µg/l	Mean
						1		95% UCL

Key

µg/l: micrograms per liter is the same as ppb: Parts per billion

95% UCL: 95% Upper Confidence Limit

WBOR: West Branch of the Ompompanoosuc River

MAX: Maximum Concentration

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in surface water (*i.e.*, the concentration that will be used to estimate the exposure and risk from each COC in surface water). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was derived.

Table 75

Summary of Chemicals of Concern and

Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current

Medium: Sediment

Exposure Medium: Sediment

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Lord Brook	Copper	8.3	209	Mg/kg	13/13	69.6	Mg/kg	Mean
						95.6		95% UCL
	Iron	4760	14400	Mg/kg	13/13	11140	Mg/kg	Mean
						12790		95% UCL
	Manganese	326	605	Mg/kg	13/13	419	Mg/kg	Mean
						456.4		95% UCL
	Selenium	ND	ND	Mg/kg	0/13	1.2	Mg/kg	Mean
						1.5		95% UCL
	Silver	0.48	0.71	Mg/kg	3/13	0.2	Mg/kg	Mean
						0.3		95% UCL
	Zinc	42	91	Mg/kg	13/13	67.1	Mg/kg	Mean
						76.9		95% UCL

Key

Mg/kg: milligram per kilogram is the same as ppm: Parts per million

95% UCL: 95% Upper Confidence Limit

MAX: Maximum Concentration

Mean: Arithmetic Mean

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in sediment (*i.e.*, the concentration that will be used to estimate the exposure and risk from each COC in sediment). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was derived.

Table 76
Summary of Chemicals of Concern and
Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Copperas Brook	Copper	163	437	Mg/kg	7/7	314.9	Mg/kg	Mean
						437		MAX
	Iron	44500	137000	Mg/kg	7/7	104929	Mg/kg	Mean
						137000		MAX
	Manganese	64.8	137	Mg/kg	7/7	98	Mg/kg	Mean
						137		MAX
	Selenium	2.17	11.8	Mg/kg	6/7	6.0	Mg/kg	Mean
						11.8		MAX
	Silver	0.32	4	Mg/kg	7/7	1.0	Mg/kg	Mean
						4		MAX
	Zinc	86	250	Mg/kg	7/7	132.2	Mg/kg	Mean
						250		MAX

Key

Mg/kg: milligram per kilogram is the same as ppm: Parts per million

95% UCL: 95% Upper Confidence Limit

MAX: Maximum Concentration

Mean: Arithmetic Mean

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in sediment (*i.e.*, the concentration that will be used to estimate the exposure and risk from each COC in sediment). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was derived.

Table 77

Summary of Chemicals of Concern and

Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current

Medium: Sediment

Exposure Medium: Sediment

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Upper Copperas Brook	Copper	748	841	Mg/kg	2/2	795	Mg/kg	Mean
						841		MAX
	Iron	107000	114000	Mg/kg	2/2	110500	Mg/kg	Mean
						114000		MAX
	Manganese	15.9	26.1	Mg/kg	2/2	21.0	Mg/kg	Mean
						26.1		MAX
	Selenium	9.5	12.8	Mg/kg	2/2	11.2	Mg/kg	Mean
						12.8		MAX
	Silver	1.4	2.2	Mg/kg	2/2	1.8	Mg/kg	Mean
						2.2		MAX
	Zinc	108	120.0	Mg/kg	2/2	114.0	Mg/kg	Mean
						120.0		MAX

Key

Mg/kg: milligram per kilogram is the same as ppm: Parts per million

95% UCL: 95% Upper Confidence Limit

MAX: Maximum Concentration

Mean: Arithmetic Mean

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in sediment (*i.e.*, the concentration that will be used to estimate the exposure and risk from each COC in sediment). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was derived.

Table 78

Summary of Chemicals of Concern and

Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current

Medium: Sediment

Exposure Medium: Sediment

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
Tributaries to Lord Brook	Copper	167	4560.0	Mg/kg	12/12	1534.7	Mg/kg	Mean
						2420.4		95% UCL
	Iron	17300	202000	Mg/kg	12/12	74067	Mg/kg	Mean
						105933		95% UCL
	Manganese	44.3	2410	Mg/kg	12/12	529	Mg/kg	Mean
						810		95% UCL
	Selenium	0.8	10.00	Mg/kg	8/12	2.05	Mg/kg	Mean
						3.31		95% UCL
	Silver	0.05	1.82	Mg/kg	11/12	0.51	Mg/kg	Mean
						0.73		95% UCL
	Zinc	62.7	557.0	Mg/kg	12/12	220.3	Mg/kg	Mean
						290.4		95% UCL

Key

Mg/kg: milligram per kilogram is the same as ppm: Parts per million

95% UCL: 95% Upper Confidence Limit

MAX: Maximum Concentration

Mean: Arithmetic Mean

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in sediment (*i.e.*, the concentration that will be used to estimate the exposure and risk from each COC in sediment). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was derived.

Table 79
Summary of Chemicals of Concern and
Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Min	Max					
WBOR Mixing Zone	Copper	5	348.00	Mg/kg	14/14	107.3	Mg/kg	Mean
						165.8		95% UCL
	Iron	5470	43100	Mg/kg	14/14	17671	Mg/kg	Mean
						23120		95% UCL
	Manganese	121	840.00	Mg/kg	14/14	340	Mg/kg	Mean
						429.2		95% UCL
	Selenium	3.1	3.10	Mg/kg	2/14	0.9	Mg/kg	Mean
						1.3		95% UCL
	Silver	0.16	1.70	Mg/kg	6/14	0.5	Mg/kg	Mean
						0.6		95% UCL
	Zinc	19.2	138.00	Mg/kg	14/14	52.0	Mg/kg	Mean
						67.2		95% UCL

Key

Mg/kg: milligram per kilogram is the same as ppm: Parts per million

95% UCL: 95% Upper Confidence Limit

MAX: Maximum Concentration

Mean: Arithmetic Mean

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

The table presents the chemicals of concern (COCs) and exposure point concentration for each of the COCs detected in sediment (*i.e.*, the concentration that will be used to estimate the exposure and risk from each COC in sediment). The table includes the range of concentrations detected for each COC, as well as the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the exposure point concentration (EPC), and how the EPC was derived.

	Table 80 Assessment and Measurement Endpoints	
Assessment Endpoint	**Risk Question**	**Measurement Endpoint(s) (Exposure and Effects)**
Aquatic Ecosystem		
Periphyton community	Are concentrations of contaminants in the surface water in waterbodies on and adjacent to the Site sufficiently elevated that they cause adverse alterations to the functioning of the periphyton community?	Determine the concentrations of Site-related metals in Site surface water. Compare concentrations of Site-related metals measured in Site surface water with hardness adjusted chronic NRWQC Compare periphyton community composition and metal uptake in periphyton inhabiting Site waterways (based upon a 2002 study by Robert Genter, Johnson State College, VT).
Benthic macroinvertebrate community	Are concentrations of contaminants in the surface water and sediments in waterbodies in and adjacent to the Site sufficiently elevated that they cause adverse alterations to the functioning of the benthic macroinvertebrate community?	Determine the concentrations of Site-related metals in Site surface water and sediment. Determine whether the SEM:AVS ratio is greater than one. Compare concentrations of Site-related metals measured in Site surface water to hardness adjusted chronic NRWQC. Compare concentrations of Site-related metals measured in Site sediment to Probable Effects Concentrations (PECs) for sediment. Using sediment toxicity bioassays, determine which sediments in and adjacent to the Site have elevated toxicity to surrogates for resident macroinvertebrate species compared to sediments in reference areas. Determine on the basis of benthic macroinvertebrate sampling and analysis where benthic communities inhabiting sediments in waterbodies in and adjacent to the Site are impaired when compared to benthic communities inhabiting reference area sediment or to water quality metrics used by the State of Vermont.
Fish community	Are concentrations of contaminants in surface waters of waterbodies in and adjacent to the Site	Determine the concentrations of Site-related metals in Site surface water. Compare concentrations of Site-related

	Table 80 Assessment and Measurement Endpoints	
Assessment Endpoint	**Risk Question**	**Measurement Endpoint(s) (Exposure and Effects)**
	sufficiently elevated that they cause adverse alterations to the functioning of the fish community?	metals measured in Site surface water hardness-adjusted chronic NRWQC. Using surface water bioassays, determine where surface waters in and adjacent to the Site have elevated toxicity to surrogates for resident fish species compared to surface water in reference areas. Compare fish community structure in Site streams to Vermont Biological Standards.
Omnivorous aquatic bird community	Are dietary exposure levels of Site-related metals sufficiently elevated to cause adverse alterations to the omnivorous aquatic avian community?	Determine the concentrations of Site-related metals in Site surface water and sediment. Through food chain models for the mallard using sediment to benthic invertebrate bioaccumulation factors, estimate the ingestion of Site-related metals and compare it to TRVs associated with adverse effects, including reproductive impairment.
Terrestrial Ecosystem		
Terrestrial plant community	Are concentrations of metals in Site soils sufficiently elevated to result in adverse alterations to the functioning of the terrestrial and wetland plant community?	Evaluate the health of the herbaceous and shrub layer community based upon field studies. Evaluate the health of the canopy layer adjacent to impacted areas using aerial photography and indicators of community impairment.
Terrestrial and wetland soil community	Are concentrations of contaminants in the soils on and adjacent to the Site mining features sufficiently elevated that they cause adverse alterations to the structure or function of the terrestrial and wetland soil community?	Determine the concentrations of Site-related metals in Site soils. Compare concentrations of metals measured in Site soils with benchmarks that have been associated with adverse effects to representative soil invertebrates.
Wetland amphibian community	Are concentrations of contaminants in Site surface water sufficiently elevated that they cause adverse	Determine the concentrations of Site-related metals in Site surface water. Compare concentrations of metals measured

	Table 80 Assessment and Measurement Endpoints	
Assessment Endpoint	**Risk Question**	**Measurement Endpoint(s) (Exposure and Effects)**
	alterations to amphibian communities?	in Site surface water hardness-adjusted chronic NRWQC. Evaluate the health of the woodland amphibian community using a call survey.
Herbivorous birds	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the herbivorous avian community?	Determine the concentrations of Site-related metals in Site soils and surface water. Through food chain models for the song sparrow using soil to vegetation bioaccumulation factors or representative tissue concentrations in plants, estimate the ingestion of Site-related metals and compare it to TRVs associated with adverse effects, including reproductive impairment.
Omnivorous birds	Are dietary exposure levels of site-related metals sufficient to cause adverse alterations to the omnivorous avian community?	Determine the concentrations of Site-related metals in Site soils and surface water. Through food chain models for the red-winged blackbird using soil to vegetation and soil to invertebrate bioaccumulation factors, or representative tissue concentrations in plants and invertebrates, estimate the ingestion of Site-related metals and compare it to TRVs associated with adverse effects, including reproductive impairment.
Insectivorous birds	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the insectivorous avian community?	Determine the concentrations of Site-related metals in Site soils, sediments and surface water. Through food chain models for the tree swallow using sediment to emergent insect bioaccumulation factors, estimate the ingestion of Site-related metals and compare it to TRVs associated with adverse effects, including reproductive impairment.
Invertivorous birds	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the invertivorous avian community?	Determine the concentrations of Site-related metals in Site soils and surface water. Through food chain models for the American robin using soil to plant and soil to invertebrate bioaccumulation factors, or representative tissue concentrations in plants and invertebrates, estimate the ingestion of Site-related metals and compare it to TRVs

	Table 80 Assessment and Measurement Endpoints	
Assessment Endpoint	**Risk Question**	**Measurement Endpoint(s) (Exposure and Effects)**
		associated with adverse effects, including reproductive impairment.
Piscivorous birds	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the piscivorous avian community or to individual ospreys?	Determine the concentrations of Site-related metals in Site sediments and surface water. Determine the concentrations of Site-related metals in fish caught in the tributaries on the site and in the WBOR. Through food chain models for the belted kingfisher and osprey using surface water to fish bioaccumulation factors as well as actual levels of Site-related metals measured in fish, estimate the ingestion of Site-related metals and compare it to TRVs associated with adverse effects, including reproductive impairment.
Carnivorous birds	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the carnivorous avian community?	Determine the concentrations of Site-related metals in Site soils and surface water. Through food chain models for the kestrel using soil to invertebrate and soil to small mammal bioaccumulation factors, estimate the ingestion of Site-related metals and compare it to TRVs associated with adverse effects, including reproductive impairment.
Herbivorous mammals	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the herbivorous mammal community?	Determine the concentrations of Site-related metals in Site soils and surface water. Through food chain models for the meadow vole and white-tailed deer using soil to plant bioaccumulation factors, or representative tissue concentrations in plants, estimate the ingestion of Site-related metals and compare it to TRVs associated with adverse effects, including reproductive impairment.
Omnivorous mammals	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the omnivorous mammal community?	Determine the concentrations of Site-related metals in Site soils and surface water. Through food chain models for the white-footed mouse using soil to plant and soil to invertebrate bioaccumulation factors, or representative tissue concentrations in plants and invertebrates, estimate the ingestion of

	Table 80 Assessment and Measurement Endpoints	
Assessment Endpoint	**Risk Question**	**Measurement Endpoint(s) (Exposure and Effects)**
		Site-related metals and compare it to TRVs associated with adverse effects, including reproductive impairment.
Insectivorous mammals	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to individual Eastern small-footed bats?	Determine the concentrations of Site-related metals in Site soils, sediments and surface water. Through food chain models for the small-footed bat using sediment to emergent insect bioaccumulation factors, estimate the ingestion of Site-related metals and compare it to TRVs associated with adverse effects, including reproductive impairment.
Invertivorous mammals	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the invertivorous mammal community?	Determine the concentrations of Site-related metals in Site soils and surface water. Through food chain models for the short-tailed shrew using soil to invertebrate bioaccumulation factors, or representative tissue concentrations in invertebrates, estimate the ingestion of Site-related metals and compare it to TRVs associated with adverse effects, including reproductive impairment.
Piscivorous mammals	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the piscivorous mammal community?	Determine the concentrations of Site-related metals in Site soils, sediments and surface water. Determine the concentrations of Site-related metals in fish caught in the tributaries on the site and in the WBOR. Through food chain models for the mink using surface water to fish bioaccumulation factors as well as actual levels of Site-related metals measured in fish, estimate the ingestion of Site-related metals and compare it to TRVs associated with adverse effects, including reproductive impairment.
Carnivorous mammals	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the carnivorous	Determine the concentrations of Site-related metals in Site soils and surface water. Through food chain models for the bobcat

	Table 80 Assessment and Measurement Endpoints	
Assessment Endpoint	**Risk Question**	**Measurement Endpoint(s) (Exposure and Effects)**
	mammal community?	using soil to mammal bioaccumulation factors, estimate the ingestion of Site-related metals and compare it to TRVs associated with adverse effects, including reproductive impairment.

Table 81
Surface Water Aquatic Life Hazard for Fish, Benthic Organisms, and Periphyton Quotients > 1 Based upon UCL_{95} Concentration and Minimum Hardness.

Analyte	Copperas Brook	Upper Copperas Brook (Between TP3 and TP2)	Lord Brook Tributaries	Lord Brook	Sargent Brook[1]	WBOR Mixing Zone	WBOR Upstream of Copperas Brook	WBOR Downstream of Mixing Zone	Ompompanoosuc River
Cadmium	103.3	840.0	30.7	2.7	--	4.0	--	--	--
Chromium		3.0			1.2				
Copper	1520.6	14834.5	693	6.6		12.7	2.4	2.3	2.0
Lead	6.8	23.0	5.6	2.5	--	2.3	2.0	1.9	2.1
Nickel	3.1	19.0	5.3		1.4	<1			
Silver	6.7	7.3		--	--	1.9	--	--	--
Zinc	36.3	316.4	19.9			1.4			
Cyanide	1.2	--	--		1.1	2.3			--

1, Based upon the maximum concentration

Table 82
Sediment Aquatic Life Hazard for Benthic Organisms Hazard Quotients > 1 for Sediments Based upon the UCL_{95}.

Analyte	Copperas Brook[1]	Upper Copperas Brook (Between TP3 and TP2)[1]	Lord Brook Tributaries	Lord Brook	Sargent Brook[1]	WBOR Mixing Zone	WBOR Upstream of Copperas Brook	WBOR Downstream of Mixing Zone	Ompompanoosuc River	Connecticut River
Copper	2.9	5.6	16.2			1.1			1.1	2.6
Manganese										1.1
Silver	1.1									

1, Based upon the maximum concentration

		Table 83 BERA Risk Characterization Summary	
Assessment Endpoint	**Risk Question**	**Conclusion of Risk Assessment**	**Identification of whether the NTCRA or Remedial Action will address the risk**
Assessment Endpoint #1: Viability and Function of Periphyton Community	Are concentrations of contaminants in the surface water in waterbodies on and adjacent to the Site sufficiently elevated that they cause adverse alterations to the functioning of the periphyton community?	The potential for significant adverse alterations to the periphyton community is present at the following exposure areas: • Copperas Brook and Upper Copperas Brook • WBOR Mixing Zone approximately to Station 42 • Drainages from South Mine, South Open Cut and TP-4 that are tributaries to Lord Brook down to the confluence with Lord Brook Outside of these areas there does not appear to be significant alterations, or the potential for significant alterations, to the structure of the periphyton community.	Implementation of NTCRA should address risk to periphyton community in Copperas Brook, Upper Copperas Brook and the WBOR Mixing Zone. Long-term maintenance of the NTCRA will be addressed by the Remedial Action. The potential for adverse alterations to the periphyton community in the mine drainage tributaries in the Lord Brook watershed will be addressed by the Remedial Action. Exposure pathways to periphyton communities in other areas on Site do not require a response action.
Assessment Endpoint #2: Viability and Function of Benthic Macroinvertebrate Community	Are concentrations of contaminants in the sediments (benthic infauna) or surface water (benthic epifauna) in waterbodies in and adjacent to the Site sufficiently elevated that they cause adverse alterations to the functioning of the benthic macroinvertebrate	The potential for significant adverse alteration to the benthic community is present at the following exposure areas: • Copperas Brook • WBOR. The most severe impacts to the WBOR occur in the Mixing Zone approximately to Station 42. Less severe but still significant	Implementation of NTCRA should address much of the risk to the benthic community in Copperas Brook, the WBOR Mixing Zone, and downstream of the WBOR Mixing Zone. Long-term maintenance of the NTCRA will be addressed by the Remedial Action. The potential for

		Table 83 BERA Risk Characterization Summary	
Assessment Endpoint	**Risk Question**	**Conclusion of Risk Assessment**	**Identification of whether the NTCRA or Remedial Action will address the risk**
	community?	impacts when compared to the reference locations and Vermont metrics for Class B surface water, extend downstream of the WBOR Mixing Zone to the confluence with the Ompompanoosuc River. The benthic community appears to achieve full recovery in the vicinity of the Union Village Dam. • Drainages from South Mine, South Open Cut and TP-4 that are tributaries to Lord Brook down to the confluence with Lord Brook • Lord Brook. The significant adverse effects to Lord Brook are found in the initial portion below the confluence with the tributaries from the source area. It is possible that impacts could extend downstream for about 1 mile in Lord Brook. In other aquatic areas on the Site there does not appear to be significant alterations, or the potential for significant alterations, to the structure of the	adverse alterations to the benthic community from surface water in the unnamed tributaries to Lord Brook will be addressed by the Remedial Action. The additional contribution of contaminants in the sediments in Copperas Brook, in the upper WBOR Mixing Zone and in the unnamed tributaries to Lord Brook also will be addressed by the Remedial Action. Exposure pathways to benthic communities in other areas on Site do not require a response action.

		Table 83 BERA Risk Characterization Summary	
Assessment Endpoint	**Risk Question**	**Conclusion of Risk Assessment**	**Identification of whether the NTCRA or Remedial Action will address the risk**
		benthic community.	
Assessment Endpoint #3: Viability and Function of Fish Community	Are concentrations of contaminants in surface waters of waterbodies in and adjacent to the Site sufficiently elevated that they cause adverse alterations to the functioning of the fish community?	The potential for significant adverse alterations to the fish community is present at the following exposure areas: • Copperas Brook • WBOR Mixing Zone approximately to Station 42 • Drainages from South Mine, South Open Cut and TP-4 that are tributaries to Lord Brook down to the confluence with Lord Brook and extending into Lord Brook The fish community appears to recover about 1 mile downstream of the confluence of the WBOR and Copperas Brook In other aquatic areas on the Site there does not appear to be significant alterations, or the potential for significant alterations, to the structure of the fish community.	Implementation of NTCRA should address much of the risk to the fish community in Copperas Brook and WBOR Mixing Zone. Long-term maintenance of the NTCRA will be addressed by the Remedial Action. The potential for adverse alterations to the fish community from surface water in the mine drainage tributaries to Lord Brook watershed will be addressed by the Remedial Action. The additional contribution of contaminants in the sediments in Copperas Brook, the upper WBOR Mixing Zone and the unnamed tributaries Lord Brook to risk in the fish community will be addressed by the Remedial Action. Exposure pathways to fish communities in other areas on Site do not require a response action.
Assessment Endpoint #4: Viability and	Are dietary exposure levels of Site-related metals sufficiently	It is unlikely that there are any significant adverse alterations to populations	This exposure pathway does not require a response action.

		Table 83 BERA Risk Characterization Summary	
Assessment Endpoint	**Risk Question**	**Conclusion of Risk Assessment**	**Identification of whether the NTCRA or Remedial Action will address the risk**
Function of Omnivorous Aquatic Bird Community	elevated to cause adverse alterations to the omnivorous aquatic avian community?	of omnivorous aquatic birds.	
Assessment Endpoint #5: Viability and Function of the Terrestrial and Wetland Plant Community	Are concentrations of metals in Site soils sufficiently elevated to result in adverse alterations to the functioning of the terrestrial and wetland plant community?	There are significant adverse impacts to the wetland and terrestrial plant community in the following exposure areas: • TP-1, TP-2 and TP-3 There appear to be minor impacts to the terrestrial and wetland plant community in the following areas: • TP-4 • Tyson's Smelter • Artesian vent However these impacts do not appear likely to substantially alter the plant communities found there. Outside of all these areas there does not appear to be significant alterations, or the potential for significant alterations, to the structure of the plant community.	Implementation of NTCRA should address the risk to plant communities at TP-1, TP-2, and TP-3. Long-term maintenance of the NTCRA will be addressed by the Remedial Action. Exposure pathways to plant communities in other areas on Site do not require a response action.
Assessment Endpoint #6: Viability and Function of the Terrestrial (Woodland) and Wetland Soil	Are concentrations of contaminants in the soils on and adjacent to the Site sufficiently elevated that they cause adverse effects on the structure or	There are significant adverse alterations to the soil community in the following exposure areas: • TP-1, TP-2, and TP-3 There appear to be minor	Implementation of the NTCRA should address the risk to soil communities at TP-1, TP-2, and TP-3. Long-term maintenance of the NTCRA will be

		Table 83 BERA Risk Characterization Summary	
Assessment Endpoint	**Risk Question**	**Conclusion of Risk Assessment**	**Identification of whether the NTCRA or Remedial Action will address the risk**
Community	function of the terrestrial and wetland soil community?	impacts to the soil community in the following areas: • TP-4 • Tyson's Smelter • Artesian vent However these impacts are unlikely to substantially impair the functioning of the soil communities found there. Outside of all these areas there does not appear to be significant alterations, or the potential for significant alterations, to the structure of the soil community.	addressed by the Remedial Action. Exposure pathways to soil communities in other areas on Site do not require a response action.

		Table 83 BERA Risk Characterization Summary	
Assessment Endpoint	**Risk Question**	**Conclusion of Risk Assessment**	**Identification of whether the NTCRA or Remedial Action will address the risk**
Assessment Endpoint #7: Viability and Function of the Woodland Amphibian Community	Are concentrations of contaminants in Site surface water sufficiently elevated that they cause adverse alterations to amphibian communities?	Comparison of surface water data with aquatic benchmarks suggests a potential impact to amphibian communities in the surface water of Copperas Brook, unnamed tributaries to Lord Brook, and the Mixing Zone of the WBOR, as well as several vernal pools within the defined waste areas at the South Open Cut, South Mine, and TP-4. The amphibian call survey suggests that there is a functioning amphibian community, however, the species composition and/or abundance may be altered by mine related contamination in surface water.	Implementation of the NTCRA should address the risk to the woodland amphibian community at TP-1, TP-2, and TP-3. Long-term maintenance of the NTCRA will be addressed by the Remedial Action. The Remedial Action will address potential impacts to amphibian communities at the South Open Cut, and in vernal pools and riparian areas of Copperas Brook, the mine drainage tributaries in the Lord Brook watershed and the upper WBOR Mixing Zone. Exposure pathways to amphibian communities in other areas on Site do not require a response action.
Assessment Endpoint #8: Viability and Function of the Herbivorous Avian Community	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the herbivorous avian community?	It is unlikely that there are any significant adverse alterations to populations of herbivorous birds.	This exposure pathway does not require a response action.
Assessment Endpoint #9: Viability and	Are dietary exposure levels of site-related metals sufficient to	It is unlikely that there are any significant adverse alterations to populations	This exposure pathway does not require a response action.

		Table 83 BERA Risk Characterization Summary	
Assessment Endpoint	**Risk Question**	**Conclusion of Risk Assessment**	**Identification of whether the NTCRA or Remedial Action will address the risk**
Function of the Omnivorous Avian Community	cause adverse alterations to the omnivorous avian community?	of omnivorous birds.	
Assessment Endpoint #10: Viability and Function of the Insectivorous Avian Community	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the insectivorous avian community?	It is unlikely that there are any significant adverse alterations to populations of insectivorous birds.	This exposure pathway does not require a response action.
Assessment Endpoint #11: Viability and Function of the Invertivorous Avian Community	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the invertivorous avian community?	It is unlikely that there are any significant adverse alterations to populations of invertivorous birds.	This exposure pathway does not require a response action.
Assessment Endpoint #12: Viability and Function of the Piscivorous Avian Community	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations, including reproductive impairment, to the piscivorous avian community or to individual ospreys?	It is unlikely that there are any significant adverse alterations to populations of piscivorous birds.	This exposure pathway does not require a response action.
Assessment Endpoint #13: Viability and Function of the Carnivorous Avian Community	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the carnivorous avian community?	It is unlikely that there are significant adverse alterations to populations of carnivorous birds.	This exposure pathway does not require a response action.
Assessment	Are dietary exposure	It is unlikely that there are	This exposure pathway

		Table 83 BERA Risk Characterization Summary	
Assessment Endpoint	**Risk Question**	**Conclusion of Risk Assessment**	**Identification of whether the NTCRA or Remedial Action will address the risk**
Endpoint #14: Viability and Function of the Herbivorous Mammal Community	levels of Site-related metals sufficient to cause adverse alterations to the herbivorous mammal community?	significant adverse alterations to populations of herbivorous mammals.	does not require a response action.
Assessment Endpoint #15: Viability and Function of the Omnivorous Mammal Community	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the omnivorous mammal community?	It is unlikely that there are any significant adverse alterations to populations of omnivorous mammals.	This exposure pathway does not require a response action.
Assessment Endpoint #16: Viability and Function of the Insectivorous Mammal Community	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations, including reproductive impairment, to individual Eastern small-footed bats.	It is unlikely that there are significant adverse alterations to populations of individual bats. Elevated hazard quotients were identified for the Copperas Brook and unnamed tributaries to Lord Brook. The relatively low level of the potential risk and the limited foraging habitat available in these areas resulted in a conclusion that individual bats and the bat community were not at risk.	This exposure pathway does not require a response action.
Assessment Endpoint #17: Viability and Function of the Invertivorous Mammal Community	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the invertivorous mammal community?	It is unlikely that there are signficant adverse alterations to populations of invertivorous mammals.	This exposure pathway does not require a response action.
Assessment	Are dietary exposure	It is unlikely that there are	This exposure pathway

		Table 83 BERA Risk Characterization Summary	
Assessment Endpoint	**Risk Question**	**Conclusion of Risk Assessment**	**Identification of whether the NTCRA or Remedial Action will address the risk**
Endpoint #18: Viability and Function of the Piscivorous Mammal Community	levels of Site-related metals sufficient to cause adverse alterations to the piscivorous mammal community?	significant adverse alterations to populations of piscivorous mammals.	does not require a response action.
Assessment Endpoint #19: Viability and Function of the Carnivorous Mammal Community	Are dietary exposure levels of Site-related metals sufficient to cause adverse alterations to the carnivorous mammal community?	It is unlikely that there are significant adverse alterations to populations of carnivorous mammals.	This exposure pathway does not require a response action.